CONCEPTUAL DESIGN AND PROGRAMMATICS STUDIES OF SPACE STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES (LSRF)

FINAL REVIEW DOCUMENT - DR3

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BY

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SPACE STATION

CONCEPTUAL DESIGNS AND PROGRAMMATICS OF SPACE STATION ACCOMMODATIONS FOR LIFE SCIENCES RESEARCH FACILITIES (LSRF)

STUDY FINAL REVIEW

JULY 24, 1985

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AGENDA

STUDY FINAL REVIEW

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CONCEPTUAL DESIGNS AND PROGRAMMATICS OF
SPACE STATION ACCOMMODATIONS FOR
LIFE SCIENCES RESEARCH FACILITIES (LSRF)

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LABORATORY OUTFITTING ORGANIZATION

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BIOASTRONAUTICS
T. M. OLCOTT, MGR.

- o VRF/VGRF
- o LSRF
- o HRF
- o RAHF
- o GPWS
- o HMF
- o ECLSS
- o CREW EQUIPMENT
- o HUMAN PRODUCTIVITY

CUSTOMER ACCOMMODATIONS
DR. M. HEINRICH

- o DR. L. ACTON, ASTROPHYSICS
- o DR. B. LICHTENBERG, CREW SYSTEMS
- o DR. S. SCHWARZKOPF, PLANT STUDIES
- o DR. L. YOUNG, LIFE SCIENCES
- o DR. J. ZIMMERMAN, ANIMAL STUDIES

SYSTEMS ENGRG
DR. W. CUTLER

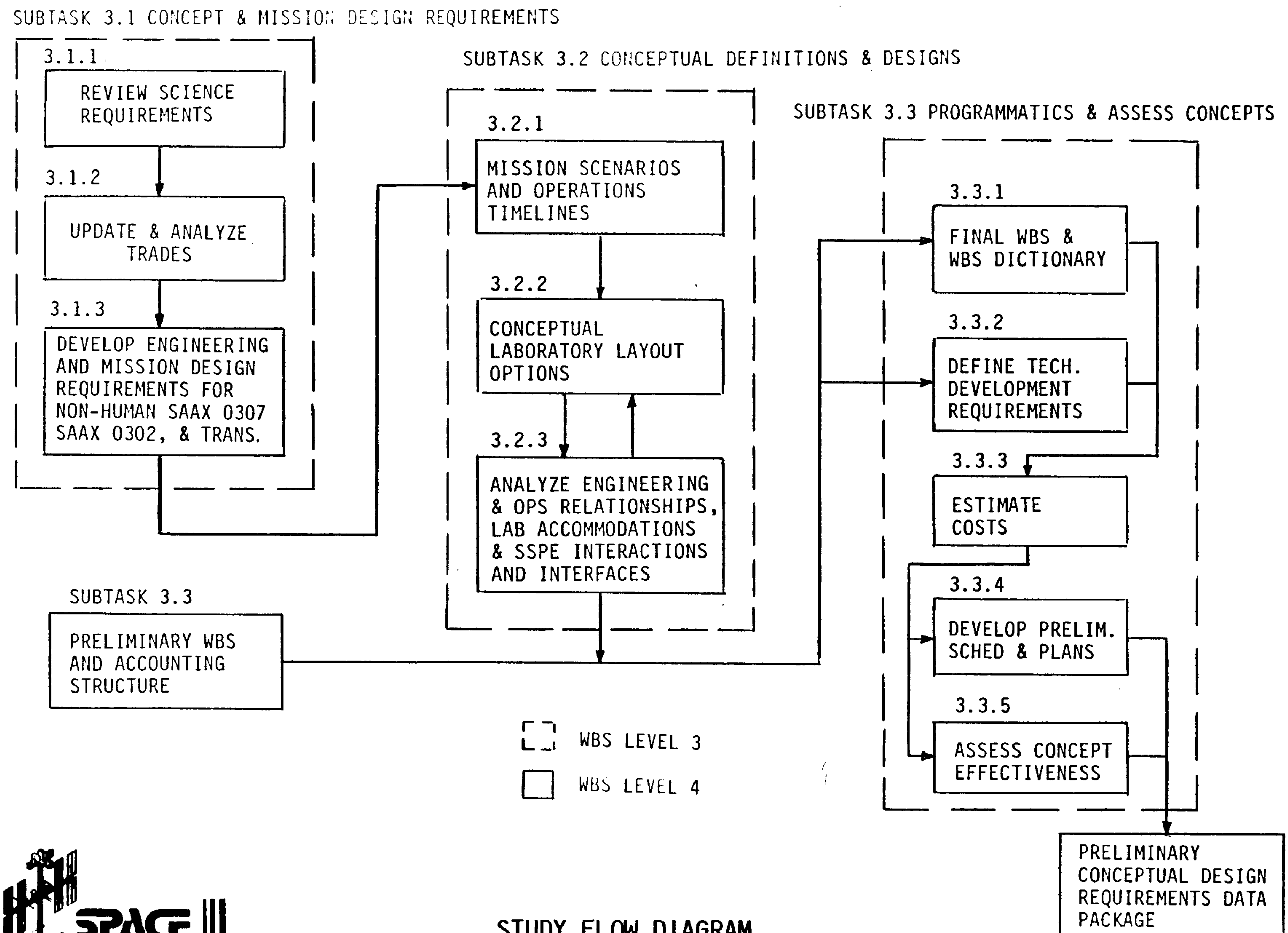
J. DIPPEL
P. DOLKAS
G. ELVENHOLL
S. FARRELL, MD
W. JESSEE
- o BIOISOLATION AD

DESIGN ENGRG
J. CERNAC

M. BALLESTRASSE
C. CHIN
C. HARRIS
K. JOHNSON
R. SWENSON
- o METABOLIC CAGE ID
- o CENTRIFUGE ID
- o CAGE WASHER ID
- o EXERCISE EQUIP ID

DATA ACQUISITION & MANAGEMENT
F. PEARLMAN

ATI S/C (INFO. & COMM. SYSTEMS)
SRI S/C (BIOCHEMICAL ANAL. AND PHYSIO. INSTRUMENTATION)
- o BIOMEDICAL DATABASE ID
- o PHYSIOLOGICAL MONITORING ID



STUDY FLOW DIAGRAM

SPACE STATION

(FINAL REPORT SUPPLEMENTS)

THE OFFICIAL LIST OF LIFE SCIENCES EXPERIMENTS IN BOTH THE ANIMAL AND PLANT AREAS IS PROVIDED BY THE "SLM QUICK LOOK DATA BASE" ORI REPORT OF APRIL 10, 1985. IN THE LOCKHEED MIDTERM REPORT OF APRIL 1985, THOSE EXPERIMENTS WERE PRIORITIZED ACCORDING TO A PERCEPTION OF THE MOST IMPORTANT STUDIES DIRECTED TOWARD CREW HEALTH PROBLEMS, THE MOST IMPORTANT SCIENTIFIC QUESTIONS, AND THE PRACTICALITY OF THE EXPERIMENTS ON THE SPACE STATION. IT IS REALIZED THAT THOSE PRIORITIES ARE HIGHLY SUBJECTIVE, AND THAT ANOTHER GROUP OR INDIVIDUAL WOULD PRODUCE A DIFFERENT LIST.

MANY OF THE CURRENT EXPERIMENTS HAVE BEEN UPDATED TO CONFORM TO PRESENT SPACE STATION PLANNING. AN EXAMPLE IS EXPERIMENT BLIA, BONE LOSS IN RATS, AS SHOWN ON THE 2 FOLLOWING CHARTS.

- MIDTERM REPORT (4/85) GAVE LOCKHEED'S PRIORITIZED LISTS OF BOTH EXPERIMENTS AND EQUIPMENT. THOSE LISTS HAVE NOT CHANGED, ALTHOUGH DIFFERENT COMBINATIONS OF BOTH HAVE BEEN CONSIDERED FOR VARIOUS MISSIONS AND MODULE CONFIGURATIONS.

- THE OFFICIAL NASA LIST OF EXPERIMENTS WILL PROBABLY CHANGE, AS A RESULT OF THE WORKSHOP OF SCIENTISTS HELD BY NASA HEADQUARTERS IN ROSSLYN 6/10/85. WE HAVE NOT YET RECEIVED THE NEW EXPERIMENTS OR PRIORITIES.

- MANY OF THE CURRENT EXPERIMENT DESCRIPTIONS HAVE BEEN UPDATED TO REFLECT CURRENT VIEWS OF SPACE STATION OPERATIONS. EXAMPLE: EXPERIMENT BL1A, BONE LOSS IN RATS.

EXPERIMENT DATA SHEET

Experiment No. BL1A

EXPERIMENT TITLE: BONE LOSS IN RATS
OBJECTIVE: Determine Effects of Microgravity on Calcium/Mineral Balance in Rats; Radiology, Histology, Biomechanics, Osteoblast Differentiation, Tooth Eruption Rate, Joints, Calcium Metabolism.

SPECIES: Rat, Mature Males	SIZE: 400-600 g	DURATION: 90 Days
SUGGESTED NUMBER: 90	STATION G LEVEL	45 (50%)
	FRACT G (Centrifuge)	
	1 G (Centrifuge)	45 (50%)

TASK	FREQUENCY	POTENTIAL FOR AUTOMATION
Vivarium: Urine/Feces Sample	2 days/week	X
RAHF/VGRF Maintenance	Every 7 days	X
Support Lab:		
Inject c̄ Fluorochromes	2 days/month	
Weigh Specimens	Every 7 days	
Blood Samples/Preserve	Every 7 days	
Sacrifice/Dissect/Preserve	6 each at 2, 10, 20, 30, 50, 85 days	
X-Ray	Every 14 days	
Bone thin sections & U-V Microscopy	At sacrifice	

EQUIPMENT - VIVARIUM	DATA
RAHF/Rodent Environment, Food & Water Consumption, Activity	DL
VGRF/Rodent Environment, Food & Water Consumption, Activity	DL
Solid & Liquid Waste Storage	-
Hand Wash Facility Cage Cleaning Facility	-

EQUIPMENT - SUPPORT LAB		DATA
Surgical Workbench	Chemical Storage (opt)	-
Mass Measurement Device (Small)	Dry Storage (opt)	-
Sacrifice Kit	Freeze Dryer (opt)	-
Blood Collection Kit	Thin Section Saw	-
Laboratory Centrifuge		-
Wet Trash Storage	X-Ray & Developer	
	X-Ray Digitizer	-
Freezer		-
Quick Freeze Unit		-
Hand Wash Facility	Binoc. Microscope	-

SAMPLE STORAGE & RETURN NO./TYPE SAMPLES	FREEZE DRY	REFRIG.	FREEZE	FIX
Bone			X	X (opt)
Feces			X	
Urine			X	
Blood			X	
Carcasses	X (opt)		X	X (opt)

SPECIMEN RETURN/SACRIFICE

20% (18) returned live
80% (72) returned sacrificed

SPECIAL ENVIRONMENTAL REQUIREMENTS (IF ANY)

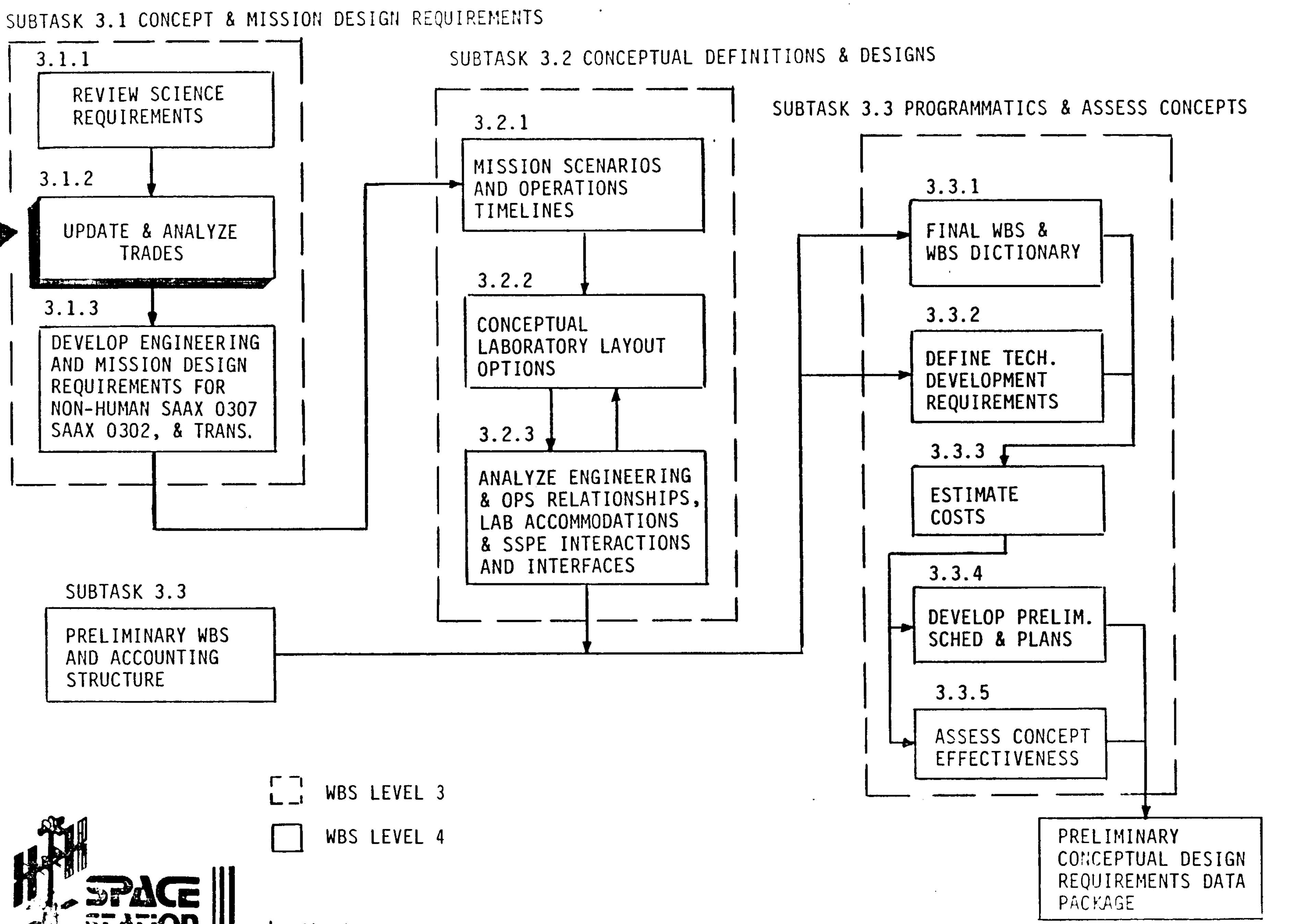
None - Because of fluorochrome injection, probably cannot be generally shared

EACH EXPERIMENT DOES NOT REQUIRE A SEPARATE GROUP OF SPECIMENS. MANY OBSERVATIONS CAN BE MADE ON ONE ANIMAL AND MANY ANALYSES ON A SINGLE BLOOD SAMPLE. IN THE CASE OF SACRIFICED SPECIMENS, ALL TISSUES SHOULD BE AVAILABLE AND SHOULD BE USED IN A VARIETY OF STUDIES. THE TISSUES WILL REQUIRE DIFFERENT PROCEDURES FOR FREEZING, FIXATION, ANALYSIS, DEPENDING ON THE EXPERIMENT.

THE NASA LIST OF EXPERIMENTS CALLS FOR MANY SPECIES. OBVIOUSLY NOT ALL SPECIES CAN BE PROVIDED IN SUFFICIENT NUMBER ON ONE MISSION. SELECTION OF SPECIES FOR A MISSION WILL DEPEND ON THE NUMBERS REQUIRED, TYPES AND SIZE OF HOLDING FACILITIES AVAILABLE, UTILITY OF SPECIMENS FOR SEVERAL EXPERIMENTS, EQUIPMENT REQUIRED, CREW TIME AND SKILLS REQUIRED, AND CEEW TIME AND SKILLS AVAILABLE, AMONG OTHER FACTORS.

CHARACTERISTICS OF LIFE SCIENCES EXPERIMENTS

- MOST EXPERIMENTS FOLLOW TIME-COURSE OF CHANGES. THUS, GROUPS OF SPECIMENS WILL BE TESTED OR DISSECTED AT INTERVALS DURING A MISSION. IMPACTS: REQUIREMENTS FOR FOOD, WATER, STORAGE, FREEZERS
- TISSUES FROM EACH SPECIMEN CAN PROBABLY BE USED FOR EXPERIMENTS IN SEVERAL DISCIPLINES, SO EACH EXPERIMENT DOES NOT REQUIRE A SEPARATE GROUP OF SPECIMENS
- ONLY A FRACTION OF TOTAL EXPERIMENT LIST CAN BE ACCOMMODATED ON A SINGLE MISSION
- MOST EXPERIMENTS WILL BE REPEATED SEVERAL TIMES ON DIFFERENT MISSIONS. REPEAT UNDER SAME CONDITIONS TO CONFIRM RESULTS; OR CHANGE CONDITIONS, BASED ON PREVIOUS RESULTS



(FINAL REPORT SUPPLEMENTS)

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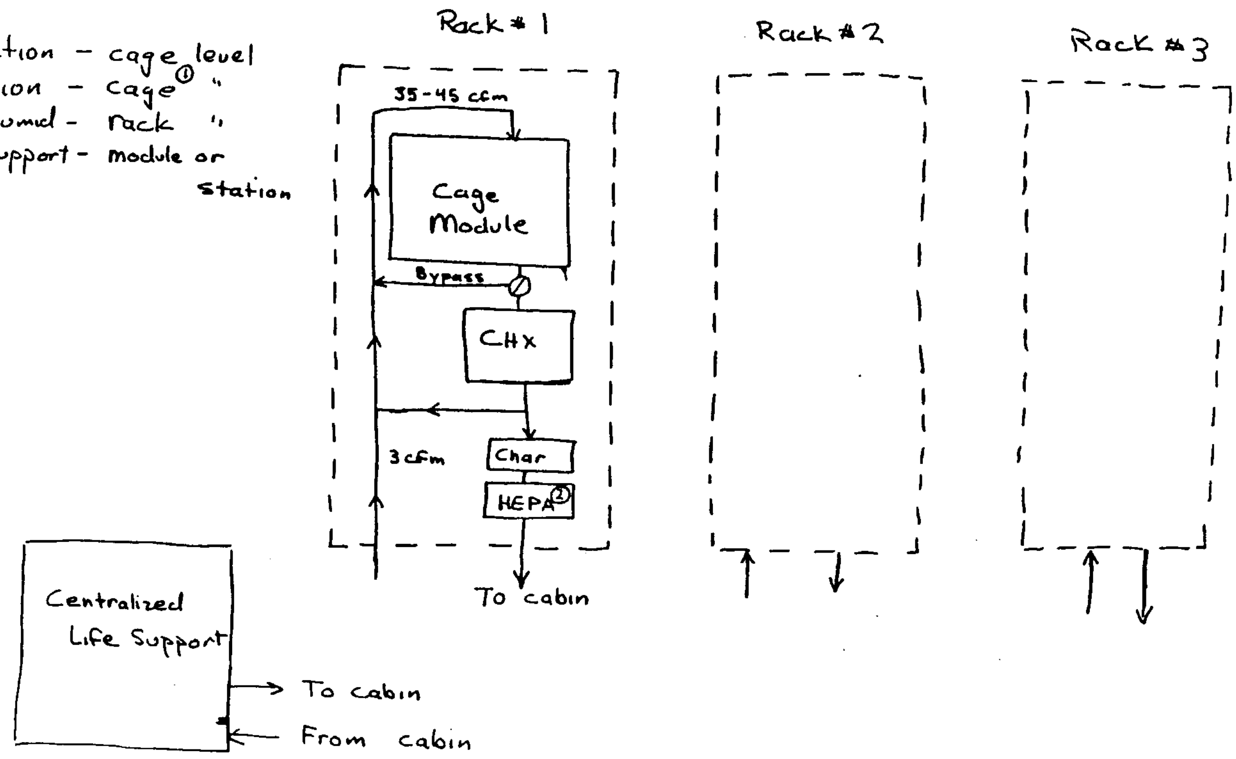
UPDATED TRADE STUDIES FROM THE DECEMBER 1984 REPORT ENCOMPASS THOSE TOPICS ITEMIZED IN THE FOLLOWING CHART. ANIMAL ECLSS AND GROWTH OPTIONS FOR LSRF ARE EMPHASIZED HERE.

- ANIMAL ECLSS
  - ARCHITECTURE (CENTRALIZED VS. DISTRIBUTED)
  - SUBSYSTEMS (OPEN VS. CLOSED VS. CABIN AIR)
- EQUIPMENT SHARING/COMMONALITY
- VIVARIUM LOCATION (IN LAB VS. LOGISTICS MODULE VS. SPECIAL MODULE)
- LOGISTICS - ANIMAL RESUPPLY
- CENTRIFUGE
  - LOCATION
  - ARCHITECTURE
- WASTE STORAGE
  - VENTING EMISSION CONTROLS

THE ANIMAL ECLSS SYSTEM FOR THE LSRF PROVIDES TEMPERATURE-HUMIDITY CONTROL, AIR CIRCULATION, AND LIFE SUPPORT (O_2 PRODUCTION AND CO_2 REMOVAL) FUNCTIONS FOR EXPERIMENTAL SUBJECTS. THREE ECLSS OPTIONS HAVE BEEN STUDIED. THE FIRST OPTION UTILIZES A SPACELAB APPROACH IN WHICH AIR CIRCULATION IS CONTROLLED AT THE CAGE, TEMPERATURE - HUMIDITY FUNCTIONS ARE CONTROLLED AT THE RACK(S) HOLDING THE CAGES, AND CREW AND EXPERIMENTAL ANIMALS UTILIZE CABIN AIR FOR THE LIFE SUPPORT FUNCTIONS.

Option # 1

Circulation - cage level
Isolation - cage ① "
Temp/Humid - rack "
Life Support - module or station



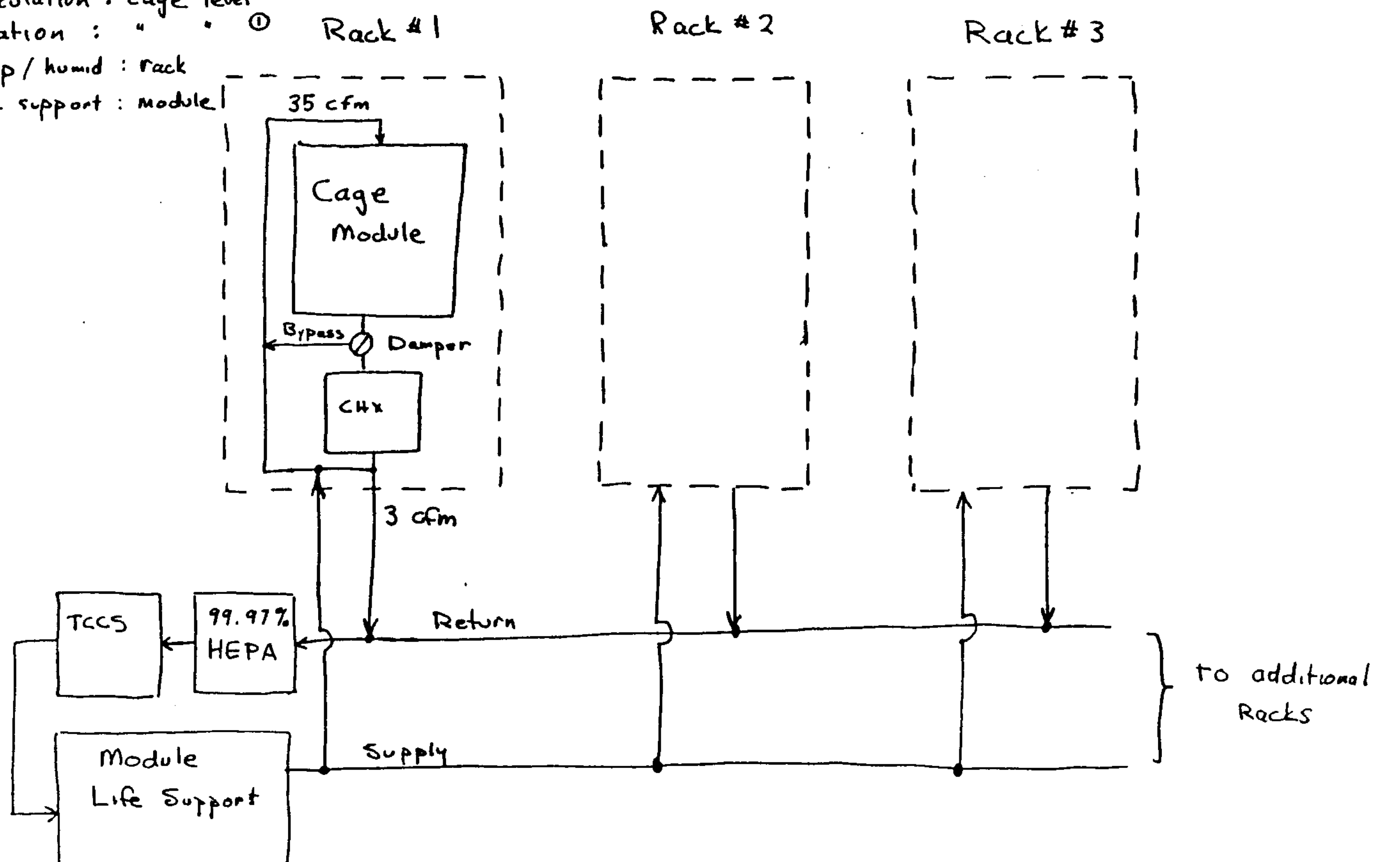
Note: ① 95 % HEPA Filter
② 99.97 % HEPA Filter

ANIMAL ECLSS - SPACELAB APPROACH

THE SECOND ECLSS OPTION UTILIZES A DEDICATED LIFE SUPPORT SYSTEM IN WHICH SEPARATE O_2 SUPPLY AND CO_2 REMOVAL SYSTEMS ARE PROVIDED FOR CREW AND EXPERIMENTAL ANIMALS. THE SECOND OPTION UTILIZES SEPARATE HEAT EXCHANGERS (CHX) FOR EACH RACK AS WELL. THIS CONFIGURATION RESULTS IN 3 CFM OF AIR PUMPED TO THE MODULE LIFE SUPPORT SYSTEM THEREBY REDUCING THE AMOUNT OF CHARCOAL REQUIRED FOR FILTRATION. AIR CIRCULATION IS CONTROLLED AT THE CAGE LEVEL.

Option # 2

Circulation : cage level
Isolation : " " ①
Temp / humid : rack
Life support : module

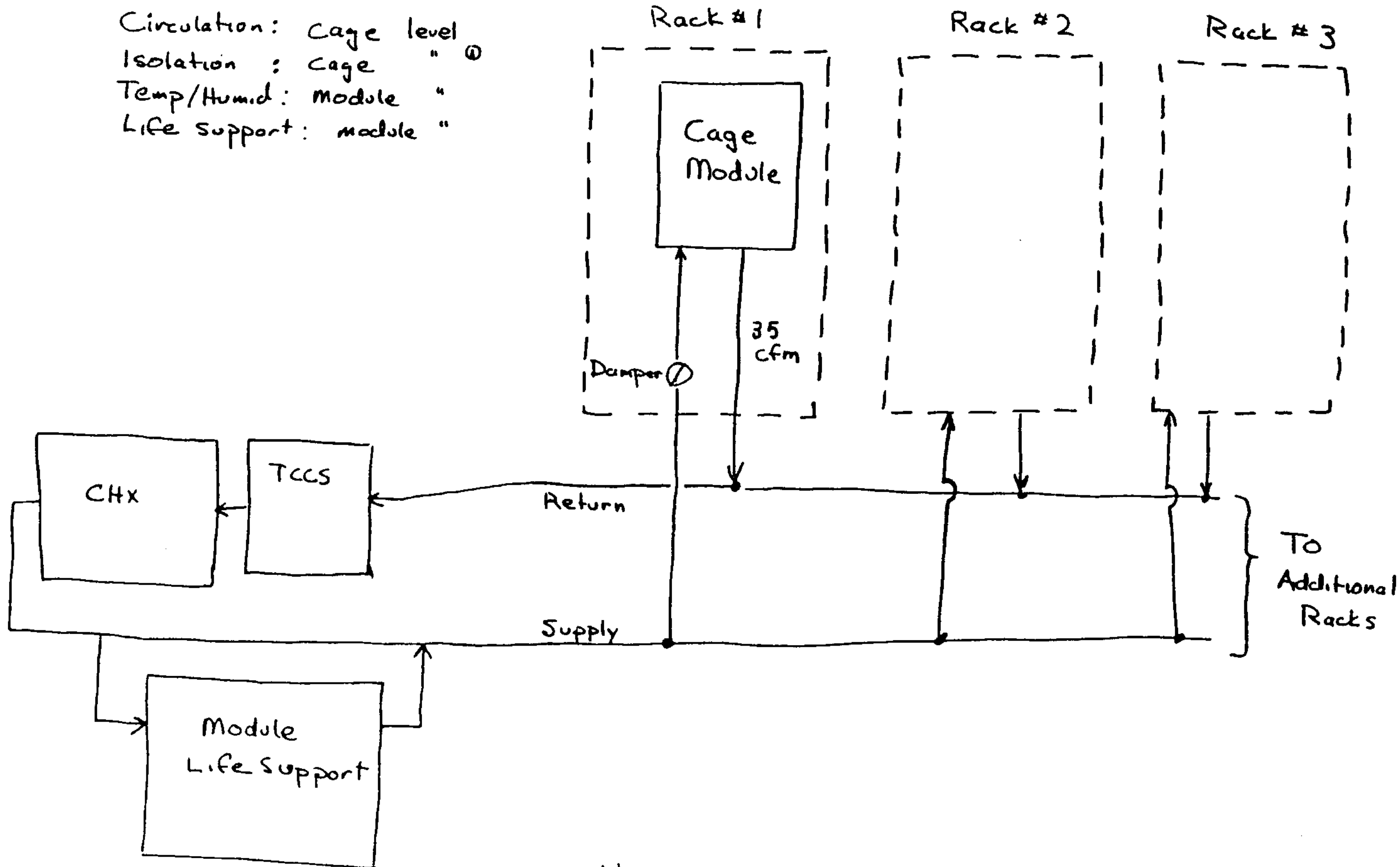


Note : ① 95 % HEPA Filter

THE THIRD OPTION ALSO UTILIZES A DEDICATED ANIMAL LIFE SUPPORT SYSTEM ANALOGOUS TO THAT USED IN OPTION 2. UNLIKE THE SECOND OPTION, HOWEVER, THE HEAT EXCHANGER IS CENTRALIZED FOR SERVICING ALL RACKS. IN THIS CONFIGURATION 35 CFM OF AIR IS PUMPED TO THE MODULE LIFE SUPPORT SYSTEM INCREASING THE FILTERING CAPACITY REQUIRED TO PURIFY THE AIR.

Option # 3

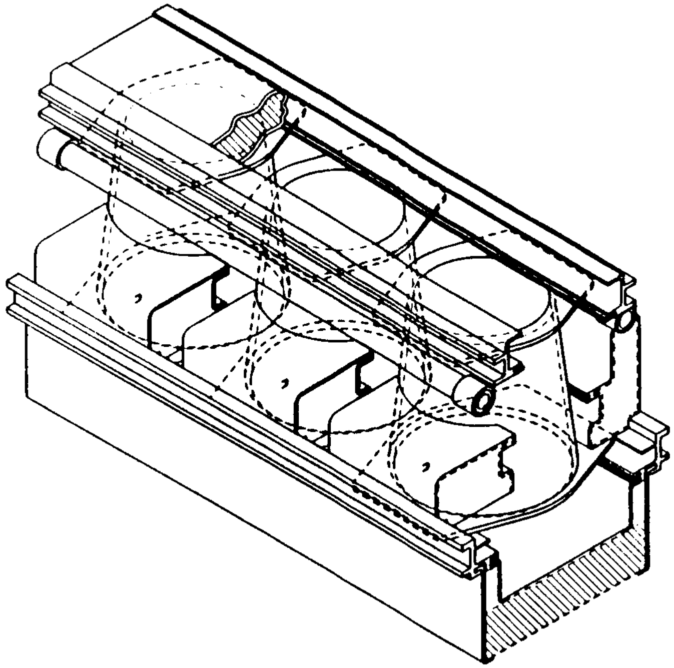
Circulation : Cage level
Isolation : Cage "
Temp/Humid : Module "
Life support : module "

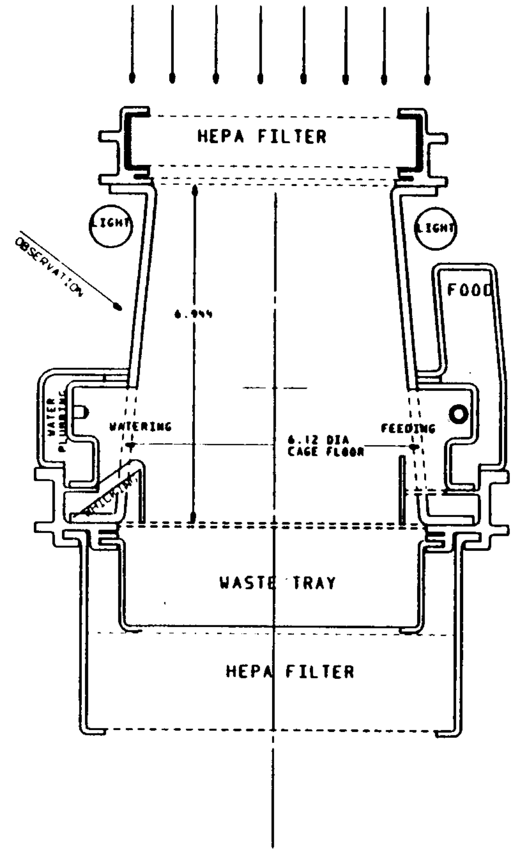


Note : 99.97% HEPA filter

CENTRALIZED ANIMAL ECLSS

PARTITION SCHEMES REALLY DO NOT PROVIDE VERY GOOD BIOLOGICAL ISOLATION. THEIR WIDESPREAD USE IN INDUSTRY STEMS FROM THE FACT THAT MOST RESEARCHERS DISLIKE WORKING INSIDE LAMINAR FLOW HOODS, PREFERRING AN OPEN BENCH TOP INSTEAD. HOWEVER, AS THE SPACELAB 3 (SL-3) FLIGHT SHOWED, THE BEST WAY TO PROVIDE TRULY EFFECTIVE ISOLATION IS TO CONTAIN CONTAMINANTS AT THEIR SOURCE AND NEVER LET THEM CONTAMINATE THE CABIN. IT IS CONCLUDED THAT THE BEST APPROACH WOULD BE TO HOUSE THE ANIMALS IN "MICROISOLATOR" CAGES, SIMILAR IN CONCEPT TO THOSE CURRENTLY USED IN INDUSTRY. ONE CONCEPT FOR A SPACE STATION VERSION IS SHOWN IN THE ACCOMPANYING CHART. THE ANIMAL, ITS FEEDER, AND WASTE TRAY ARE HOUSED BETWEEN TOP AND BOTTOM MICROBIAL FILTERS. AIRFLOW IS FROM THE TOP OF THE CAGE TO THE BOTTOM TO AID IN GETTING THE ANIMAL WASTE INTO THE WASTE TRAY.





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FLOW-THROUGH MICROISOLATION CAGE

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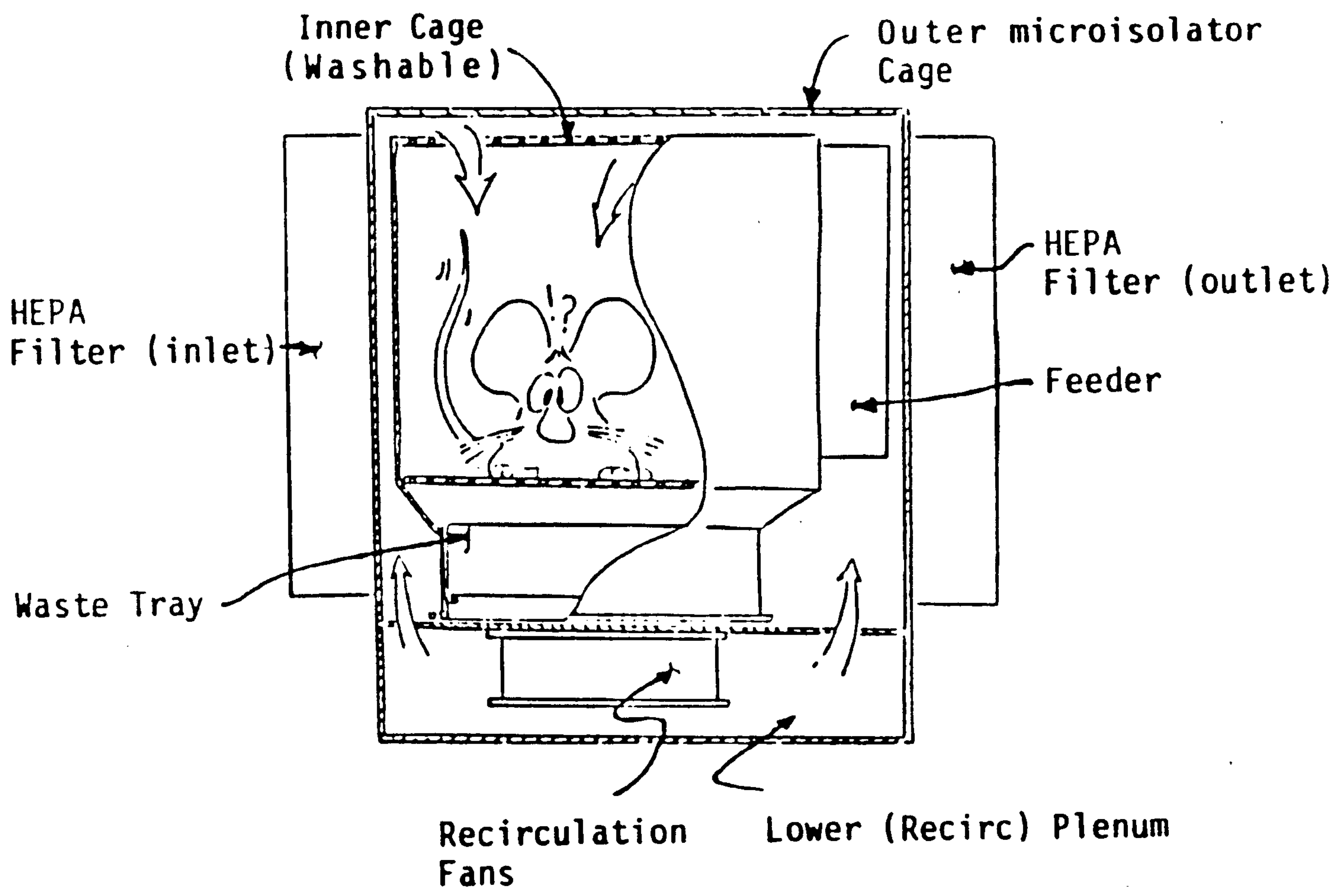
GETTING AN APPRECIABLE AIRFLOW THROUGH THE MICROBIAL FILTERS IN THE DESIGN SHOWN ON THE PREVIOUS CHART REQUIRES CONSIDERABLE FAN POWER; CONSEQUENTLY THE AIR VELOCITY INSIDE THE CAGE IS LIKELY TO BE LIMITED TO 0.1 - 0.15 MPS. THIS AIR VELOCITY IS NOT ENOUGH TO GIVE THE ANIMAL A PREFERRED ORIENTATION (I.E. BACKSIDE TOWARD THE DRAFT). THEREFORE, THE ANIMAL WAS SELDOM POINTED TOWARD THE WASTE TRAY ON THE SL-3 ENGINEERING FLIGHT TEST OF THE RESEARCH ANNUAL HOLDING FACILITY (SEE SECTION 7). THUS THE UPPER MICROBIAL FILTER WOULD HAVE TO BE PROTECTED BY A "SPLASH GUARD" TO PREVENT THE ANIMAL FROM URINATING ON IT. THE DUAL MICROISOLATOR CAGE CONCEPT SHOWN HERE SOLVES THESE PROBLEMS.



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DUAL MICROISOLATOR CAGE CONCEPT

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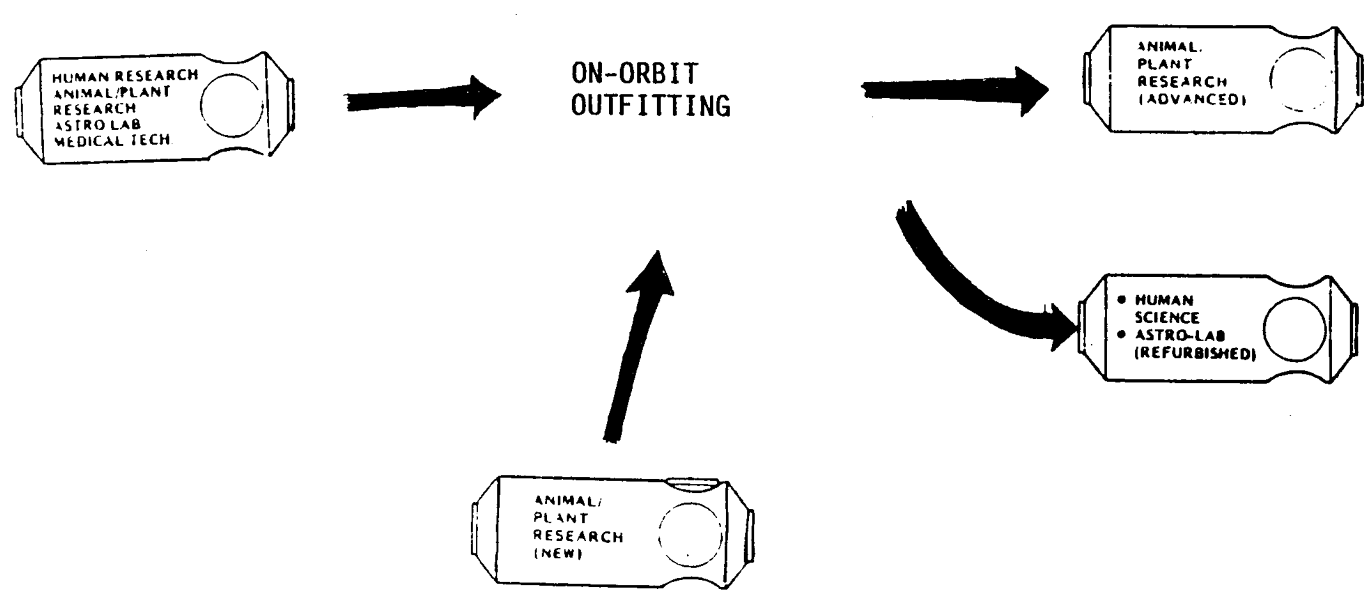
TWO GROWTH OPTIONS WERE CONSIDERED FOR TRANSITIONING THE COMMON MODULE LSRF (SAAX 0307) TO A DEDICATED LSRF (SAAX 0302). THE FIRST OPTION REQUIRES THAT NEW ANIMAL-PLANT RESEARCH EQUIPMENT, INCLUDING THE CENTRIFUGE AND ANIMAL ECLSS, BE INTEGRATED WITH THAT CONTAINED IN THE COMMON LAB TO FORM A DEDICATED LSRF MODULE.

COMMON MODULE



- o CENTRIFUGE
- o ANIMAL ECLSS

SPACE STATION

GROWTH OPTIONS

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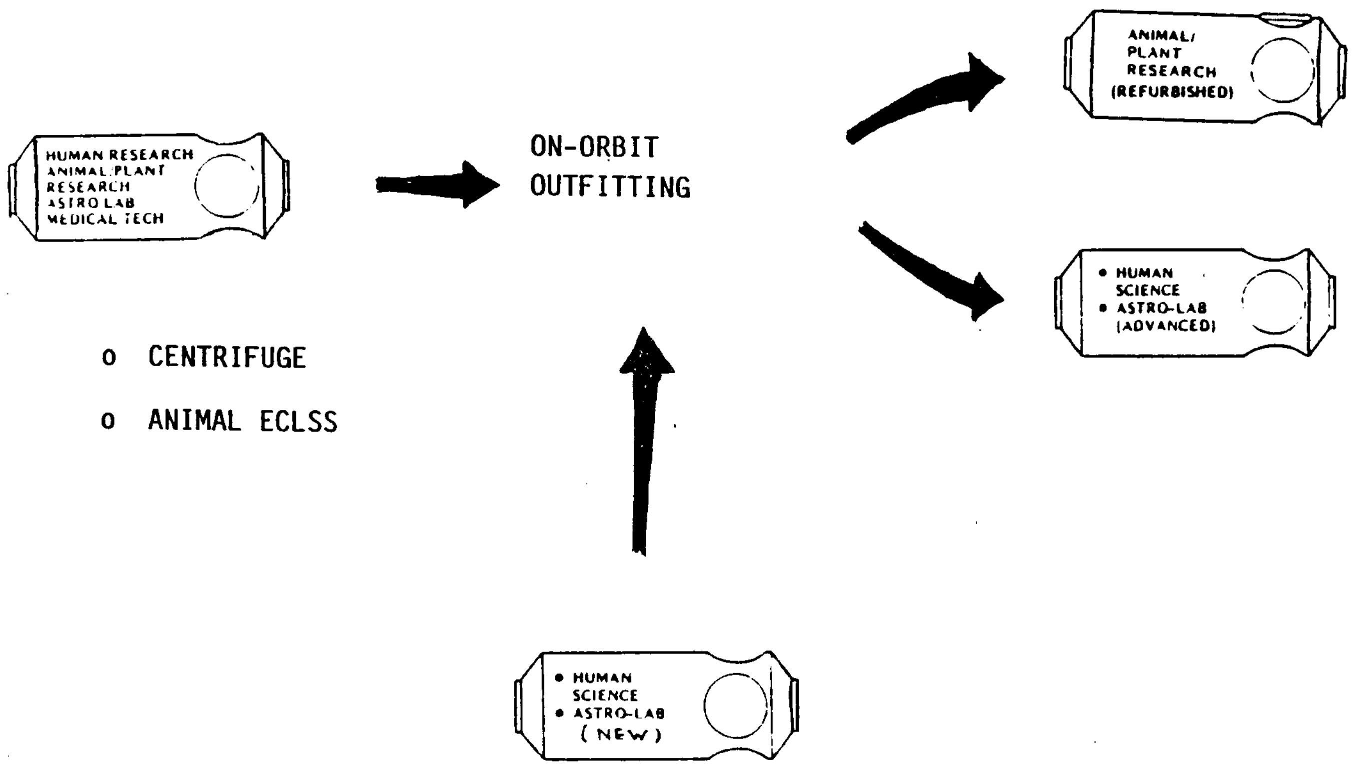
THE SECOND OPTION ASSUMES THAT THE CENTRIFUGE AND ANIMAL ECLSS ARE PART OF THE IOC COMMON LAB MODULE AND THAT THE HUMAN RESEARCH EQUIPMENT PORTION OF THE COMMON LAB WILL BE TRANSITIONED ON-ORBIT TO THE NEW HUMAN SCIENCE AND ASTRO-LAB EQUIPMENT MODULE DEDICATED TO HUMAN RESEARCH. THIS APPROACH MINIMIZES CHANGEOUT OF LARGE EQUIPMENT ITEMS (E.G., CENTRIFUGE) ON-ORBIT.



SPACE STATION

GROWTH OPTIONS

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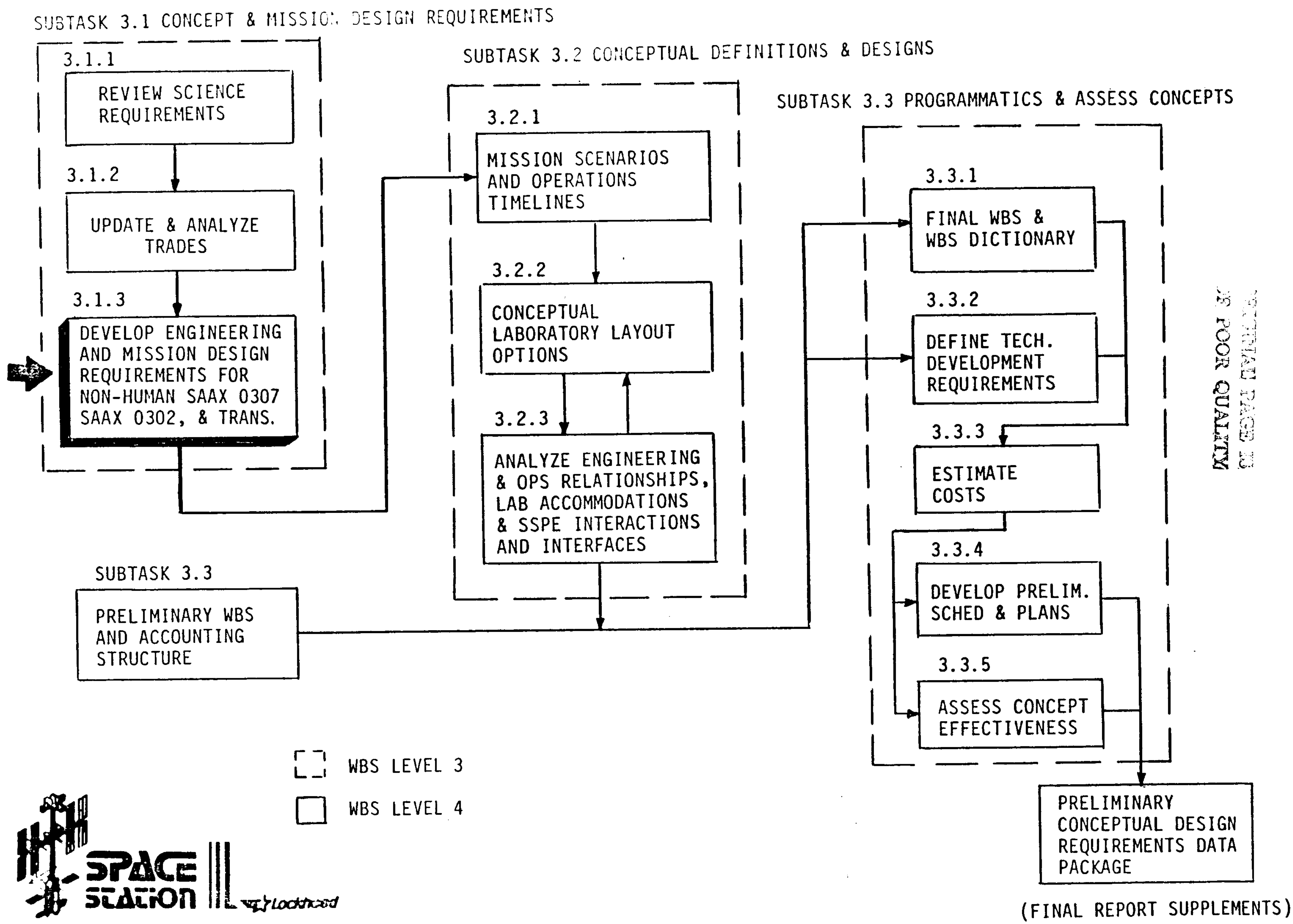
SUBTASK 3.1 CONCEPT & MISSION DESIGN REQUIREMENTS
3.1.1
REVIEW SCIENCE REQUIREMENTS
3.1.2
UPDATE & ANALYZE TRADES
3.1.3
DEVELOP ENGINEERING AND MISSION DESIGN REQUIREMENTS FOR NON-HUMAN SAAX 0307 SAAX 0302, & TRANS.
SUBTASK 3.2 CONCEPTUAL DEFINITIONS & DESIGNS
3.2.1
MISSION SCENARIOS AND OPERATIONS TIMELINES
3.2.2
CONCEPTUAL LABORATORY LAYOUT OPTIONS
3.2.3
ANALYZE ENGINEERING & OPS RELATIONSHIPS, LAB ACCOMMODATIONS & SSPE INTERACTIONS AND INTERFACES
SUBTASK 3.3 PROGRAMMATICS & ASSESS CONCEPTS
3.3.1
FINAL WBS & WBS DICTIONARY
3.3.2
DEFINE TECH. DEVELOPMENT REQUIREMENTS
3.3.3
ESTIMATE COSTS
3.3.4
DEVELOP PRELIM. SCHED & PLANS
3.3.5
ASSESS CONCEPT EFFECTIVENESS
SUBTASK 3.3
PRELIMINARY WBS AND ACCOUNTING STRUCTURE
PRELIMINARY CONCEPTUAL DESIGN REQUIREMENTS DATA PACKAGE
(FINAL REPORT SUPPLEMENTS)
WBS LEVEL 3
WBS LEVEL 4
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REQUIREMENTS DOCUMENTATION IS NECESSARY TO SUPPORT THE DESIGN OF THE LSRF SYSTEM. THIS DOCUMENTATION IS TO CONSIST OF A SPECIFICATION AND ASSOCIATED ICDs. REQUIREMENTS ANALYSIS IS THE PROCESS FOR DETERMINING THE FORM AND CONTENT OF THIS DOCUMENTATION. WE HAVE CHOSEN THE MIL-STD-490 TYPE A SYSTEM SPECIFICATION TO FACILITATE DEVELOPMENT OF LSRF REQUIREMENTS. COMPLETION OF THE DETAILS OF THIS REQUIREMENTS DOCUMENT IS A TASK FOR FUTURE WORK.

ALTHOUGH SOME PARAGRAPHS OF THE MIL-STD-490 MODEL DO NOT APPLY, THIS APPROACH HAS TWO ADVANTAGES: (1) THE OUTLINE PROVIDES A THOROUGHLY TESTED CHECKLIST WHICH ENSURES COMPLETE CONSIDERATION OF ALL RELEVANT ASPECTS OF THE REQUIREMENT, AND (2) THE OUTLINE IS FAMILIAR WITHIN THE INDUSTRY AND CAN BE FOLLOWED EASILY BY EXPERIENCED PEOPLE. SOME OF THE MORE PERTINENT PARAGRAPHS ARE DESCRIBED BRIEFLY IN THE FOLLOWING MATERIAL. THE PARAGRAPH NUMBERS IN PARENTHESIS ARE THOSE FROM THE MIL-STD-490 FORMAT.

SCOPE (PARA. 1.1) THE SPECIFICATION ESTABLISHES PERFORMANCE, DESIGN, DEVELOPMENT, AND TEST REQUIREMENTS FOR THE LSRF SYSTEM.

GENERAL DESCRIPTION (PARA. 3.1.1) THE LSRF SYSTEM CONSISTS OF THE OUTFITTING OF THE COMMON MODULE ASSIGNED TO THE LSRF, THE ASSOCIATED GROUND SEGMENT AND STS EQUIPMENT AND FACILITIES, SOFTWARE, AND DOCUMENTATION.

SYSTEM FUNCTIONS (PARA. 3.1.4.1) SINCE, AS DESCRIBED ABOVE, THE LSRF PERFORMS NO SINGLE FUNCTION, SERVING AS A FACILITY AT THE DISPOSAL OF A COMMUNITY OF USERS, THE DEFINITION OF LSRF SYSTEM FUNCTIONS BECOME THE PHASES OF THE LSRF SYSTEM LIFE CYCLE.

SYSTEM COMPOSITION (PARA 3.1.4.2) THE LSRF SYSTEM CONSISTS OF EQUIPMENT ITEMS, GROUPED AS DEFINED IN PARA. 3.2 AND DESCRIBED IN MORE DETAIL IN PARA. 3.7, PLUS OPERATIONS.

- o SCOPE
  - OPERATION, PERFORMANCE, DESIGN, DEVELOPMENT, TEST
- o APPLICABLE DOCUMENTS
  - SPACE STATION PROGRAM DESCRIPTION, MISSION DEFINITIONS, STANDARDS, ICDs
- o GENERAL DESCRIPTION
  - OUTFITTING (EQMT, INTERFACES, MODS TO COMMON MODULE)
  - GROUND AND STS EQUIPMENT
  - SOFTWARE
  - DOCUMENTATION
- o MISSIONS
  - NONHUMAN LIFE SCIENCE RESEARCH
  - SPACE STATION EQUIPMENT AND SAFE HAVEN
  - FULL LIFE CYCLE
- o FUNCTIONS AND COMPOSITION
  - FUNCTIONS - LIFE CYCLE, OPERATIONS
  - COMPOSITION - EQUIPMENT GROUPINGS

INTERFACE DEFINITION (PARA. 3.1.5) THE LSRF SYSTEM HAS EXTERNAL INTERFACES WITH THE REST OF THE SPACE STATION, THE STS, GROUND FACILITIES, AND CUSTOMERS. THESE WILL BE DEFINED IN APPROPRIATE TOP-LEVEL ICDs. THE LSRF SYSTEM ALSO HAS INTERNAL INTERFACES AMONG AND WITHIN THE EQUIPMENT GROUPINGS. THESE WILL BE DEFINED IN APPROPRIATE LOWER-LEVEL INTERFACES (AT THE LEVEL OF THE INDIVIDUAL DESIGN ITEMS).

INTERFACES

- o SPACE STATION
  - CREW LOADS
  - POWER, THERMAL, EMC, ETC.
  - CONTAMINATION
  - MICRO-G AND REBOOST
  - SERVICING
  - OUTFITTING ACCESS
- o SHUTTLE
  - LAUNCH LIMITS - VOLUME, SHAPE, MASS
  - SUPPORT FUNCTIONS DURING LAUNCH AND RETURN
  - ALLOCATED ON-ORBIT FUNCTIONS (NOT LIKELY)
- o GROUND (SEE 3.2.3)
  - PLANNING, PREPARATION, LOGISTICS, DATA AND CONTROL
- o CUSTOMER
  - EQUIPMENT, PROCEDURES, DATA, SAFETY, TEST AND VERIFICATION

OPERATIONAL AND ORGANIZATIONAL CONCEPTS (PARA. 3.1.7) THE FOLLOWING ARE INCLUDED: PROCEDURES, ORGANIZATION, SUPPORT EQUIPMENT, RESOURCES, AND FACILITIES FOR DESIGN, PRODUCTION, ASSEMBLY/DEPLOYMENT, VERIFICATION AND TEST, OPERATION (FLIGHT, LAUNCH-RETURN, AND GROUND), GROWTH, AND DISPOSAL.

OPERATIONAL AND ORGANIZATIONAL CONCEPTS

- o LIFE-CYCLE ORIENTED
  - VERIFICATION AND TEST
  - ASSEMBLY AND DEPLOYMENT
  - EXPERIMENT OPERATIONS
    - PRE-LAUNCH AND POST-LANDING
    - FLIGHT AND GROUND OPS
    - RESUPPLY
  - SERVICING
- o ROLE OF FLIGHT CREW, GROUND CREW, PI TEAM
- o COORDINATION WITH SPACE STATION
  - CREW ACTIVITY
  - CONCURRENT MISSIONS
  - STS DOCKING, REBOOST, ETC.

PERFORMANCE CHARACTERISTICS (PARA. 3.2.1) IDENTIFY SYSTEM FUNCTIONS AND PERFORMANCE ATTRIBUTES FROM SCIENTIFIC OBJECTIVES, THE NEEDS OF EACH PI THROUGHOUT THE LIFE CYCLE OF AN EXPERIMENT, AND THE FUNCTIONS NECESSARY TO SUPPORT THESE. QUANTIFY WHERE POSSIBLE, IN AREAS SUCH AS ENVIRONMENT, RESOURCES, EQUIPMENT PRECISION, AND AVAILABILITY. OTHERWISE STATE FUNCTIONS AND LOGICAL OR SEQUENTIAL RELATIONSHIPS.

PERFORMANCE

- o OPERATIONAL TIMELINES
  - INTEGRATE COMPATIBLE ACTIVITIES
  - SEPARATE CONFLICTING ACTIVITIES
  - MAXIMIZE PRODUCTIVITY
- o EQUIPMENT PERFORMANCE
  - ENVIRONMENTS: ATMOSPHERE, TEMPERATURE, ETC.
  - MEASUREMENTS: PARAMETERS, RANGE AND ACCURACY
  - FUNCTIONS: OPERATING MODES, COMMAND, AUTOMATION
  - RESOURCE ALLOCATIONS: POWER, THERMAL, ETC.
  - DATA SUPPORT ALLOCATIONS

PHYSICAL CHARACTERISTICS (PARA 3.2.2) IDENTIFY THE EQUIPMENT GROUPINGS AND THE ITEMS THEY CONTAIN, WITH WHICH THE LAB IS OUTFITTED. DEFINE ALLOCATIONS FOR WEIGHT, SPACE, ACCESS, ETC. ALSO DEFINE FLOORS AND PARTITIONS, WINDOWS AND PORTS, AIRLOCKS, AND RETENTION MEANS FOR EQUIPMENT AND PERSONNEL.

RELIABILITY (PARA. 3.2.3) ALLOCATE RELIABILITY REQUIREMENTS TO INDIVIDUAL ITEMS AND SPECIFY THE METHOD OF COMPUTATION. INCLUDE REDUNDANCY, FAULT-TOLERANCE, AND VARIOUS WORK-AROUND OR DEGRADED MODES AS A MEANS TO QUANTIFY RELIABILITY.

MAINTAINABILITY (PARA. 3.2.4) SPECIFY MAINTAINABILITY FEATURES AND CRITERIA TO BE APPLIED AT EACH LEVEL OF DESIGN, FROM OVERALL LSRF OUTFITTING TO THE LOWEST LEVEL OF EQUIPMENT COVERED. THE REQUIREMENTS WILL BE DETERMINED IN CONJUNCTION WITH CUSTOMER SERVICING, AND WILL IN GENERAL CONSIST OF A RANGE OF OPTIONS TO BE UTILIZED AS APPROPRIATE IN EACH SPECIFIC CASE.

AVAILABILITY (PARA. 3.2.5) AVAILABILITY IS A PREREQUISITE TO PRODUCTIVITY. AVAILABILITY GOALS WILL BE ACHIEVED THROUGH A COMBINATION OF RELIABILITY, MAINTAINABILITY, CAPABILITY TO MEET OPERATIONAL LOADS, AND LOGISTICS.

SYSTEM EFFECTIVENESS MODELS (PARA. 3.2.6) SYSTEM EFFECTIVENESS MODELS WILL BE DEVELOPED FROM STUDIES AND TRADES IN AREAS SUCH AS CUSTOMER ACCOMMODATIONS, CREW PRODUCTIVITY, AUTONOMY, AND AUTOMATION AND ROBOTICS. AS SYSTEM EFFECTIVENESS MODELS ARE DEVELOPED, THEY WILL BE INCLUDED IN THE SPECIFICATION.

PHYSICAL CHARACTERISTICS

- TIME-PHASED EQUIPMENT LISTS
- MASS, SHAPE, VOLUME
- ACCESS
- FLOORS, PARTITIONS, FURNISHINGS, ETC.

SPECIAL TOPICS

- RELIABIBILITY, MAINTAINABILITY, AVAILABILITY REQUIREMENTS ALLOCATED BY TRADING EQUIPMENT COST AGAINST LOST LAB PRODUCTIVITY
- SYSTEM EFFECTIVENESS MODELS: QUANTIFY SYSTEM PERFORMANCE VERSUS DESIGN OPTIONS IN AREAS SUCH AS OPERATIONS, LOGISTICS, ETC.

ENVIRONMENTAL CONDITIONS (PARA. 3.2.7) THIS SECTION COVERS THE EXTERNAL NATURAL AND MAN-MADE ENVIRONMENTS IMPINGING ON THE LSRF DURING ALL STAGES OF ITS LIFE CYCLE. THE MAIN CONSIDERATION IS THE SPACE ENVIRONMENT: RADIATION, MICROMETEORITES, CONTAMINATION FROM OTHER PORTIONS OF THE SPACE STATION, ETC. EMI/RFI/EMC ARE EXPLICITLY INCLUDED IN PARA. 3.3.2.

MATERIALS, PROCESSES, AND PARTS (PARA. 3.3.1) PROVIDE STANDARDS FOR MATERIALS, PROCESSES, TOLERANCES, FASTENERS, JOINING, FITTINGS, MECHANISMS, CONNECTIONS AND WIRING, SEALS, COATINGS FOR ALL EQUIPMENT, SECONDARY STRUCTURE, SUBSYSTEMS, AND COMPONENTS. SUCH STANDARDS AS APPLY TO THE SPACE STATION, STS, OR GROUND SEGMENT AS A WHOLE SHALL BE INCLUDED BY REFERENCE. STANDARDS APPLICABLE SPECIFICALLY TO THE LSRF WOULD INCLUDE COMPATIBILITY WITH SPECIMENS, CLEANING AND STERILIZABILITY, HANDLING AND COMPATIBILITY OF REAGENTS, PHARMACEUTICALS, SOLVENTS, AND CLEANING AGENTS, AND SIMILAR ISSUES.

ELECTROMAGNETIC RADIATION. (PARA. 3.3.2) DEFINE REQUIREMENTS GOVERNING INADVERTENT EMI/RFI/EMC, BOTH EXTERNAL AND INTERNAL TO THE LSRF SYSTEM. NOTE, THE INTERNATIONAL ASPECTS OF EMI/RFI/EMC ARE COVERED IN PARA. 3.1.5, INTERFACES.

DESIGN (PARA. 3.3) ESTABLISH RECOMMENDED DESIGN APPROACHES (E.G., SECONDARY STRUCTURES AND PLUMBING), GOING BEYOND THE STANDARDS DEFINED IN PARA. 3.3.1.

COMMONALITY, STANDARDIZATION, AND INTERCHANGEABILITY. (PARA 3.3.5) ESTABLISH REQUIREMENTS REGARDING IMPLEMENTATION OF THESE ATTRIBUTES, BOTH INTERNAL AND EXTERNAL TO THE LSRF SYSTEM.

SAFETY. (PARA. 3.3.6) ESTABLISH REQUIRED LEVELS OF SAFETY. PLACE LIMITS ON UNSAFE EQUIPMENT OR PRACTICES. DEFINE ACCEPTABLE MEANS OF CONTROLLING OR MITIGATING HAZARDS.

- o ENVIRONMENTS
  - GROUND AND LAUNCH ENVIRONMENT
  - NATURAL SPACE ENVIRONMENT (RADIATION, ETC.)
  - COMPOSITE SPACE STATION ENVIRONMENT (CONTAMINATION, EMI)
- o DESIGN AND CONSTRUCTION
  - MATERIALS, PROCESSES, PARTS
  - DESIGN STANDARDS
  - ISSUES: COMPATIBILITY WITH SPACE STATION
    COMPATIBILITY WITH LIFE SCIENCE
- o SAFETY
  - HAZARD IDENTIFICATION
  - EQUIPMENT STANDARDS
  - OPERATIONS STANDARDS

HUMAN ENGINEERING. (PARA. 3.3.7) ESTABLISH REQUIREMENTS ON THE MAN-MACHINE INTERFACE, AND ON THE GENERAL SENSORY ENVIRONMENT WITHIN THE LSRF, SO AS TO ENHANCE THE PRODUCTIVITY AND WELL-BEING OF THE CREW.

DOCUMENTATION. (PARA. 3.4) DEFINE THE NECESSARY DOCUMENTATION AND THE STANDARDS IT IS TO MEET.

LOGISTICS. (PARA. 3.5) DEFINE THE REQUIREMENTS ON LOGISTICS, AS FLOWING FROM THE GENERAL OPERATIONAL CONCEPT AND PERFORMANCE REQUIREMENTS AS DEFINED ABOVE.

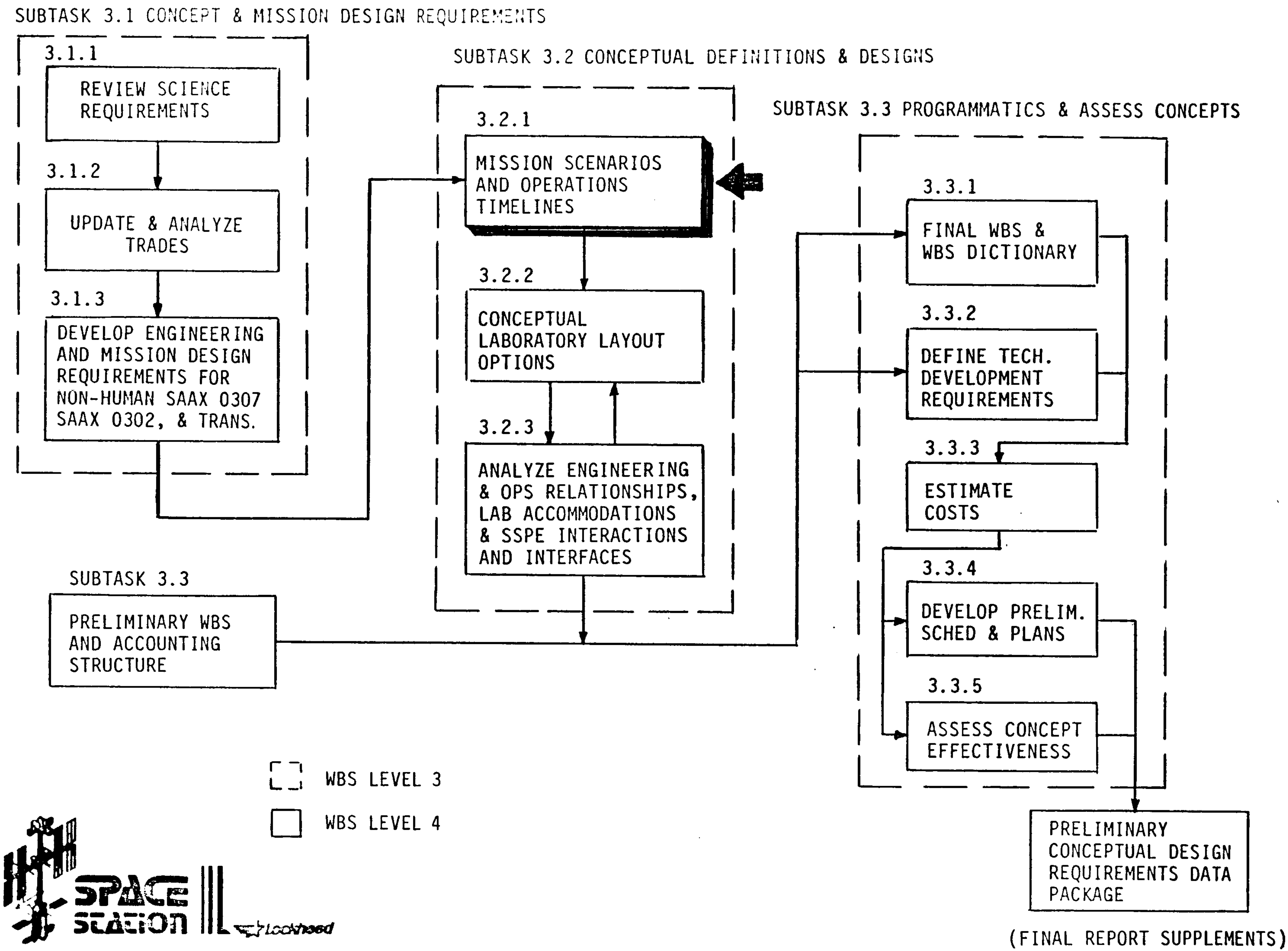
PERSONNEL AND TRAINING. (PARA. 3.6) DEFINE THE PERSONNEL COMPLEMENT FOR THE LSRF, EITHER AS DERIVED FROM FUNCTIONAL AND OPERATIONAL REQUIREMENTS, OR AS ALLOCATED FROM HIGHER LEVELS. DEFINE THE REQUIRED RESPONSIBILITIES AND SKILLS, AND THE NECESSARY TRAINING PROGRAM AND FACILITIES.

EQUIPMENT GROUPING CHARACTERISTICS. (PARA. 3.7) FOR EACH OF THE EQUIPMENT GROUPINGS DEFINED IN PARA. 3.2.2, REITERATE THE ATTRIBUTES DEFINED IN PARAS. 3.2 AND 3.3, AT A GREATER LEVEL OF DETAIL. THESE BECOME IN EFFECT THE DESIGN REQUIREMENTS FOR EACH EQUIPMENT GROUPING, TO BE INCORPORATED IN A DESIGN SPECIFICATION FOR THAT GROUPING, AND FLOWED DOWN TO THE INDIVIDUAL EQUIPMENT ITEMS IN THE GROUPING.

QUALITY ASSURANCE (PARA 4.1.4) DEFINE THE RESPONSIBILITY AND THE MEANS WHEREBY THE CONFORMANCE OF THE LSRF SYSTEM TO ITS REQUIREMENTS WILL BE VERIFIED. THIS SECTION FORMS THE BASIS FOR THE TEST AND VERIFICATION PLAN.

THE BRIEF PARAGRAPH DESCRIPTIONS ABOVE ARE TO INDICATE THE DIRECTION PROPOSED FOR THE LSRF SYSTEM REQUIREMENTS ANALYSIS.

- HUMAN ENGINEERING
  - ERGONOMETRICS
  - UNDERSTANDABILITY/OPERABILITY OF EQUIPMENT
  - WORK LOAD
  - AESTHETICS
- LOGISTICS
  - GROUND, SHUTTLE, SPACE STATION SUPPORT FACILITIES
  - RESUPPLY SCHEDULE
- TRAINING
  - GENERAL ACADEMIC BACKGROUND AND SKILL
  - EXPERIMENT - SPECIFIC
- QUALITY ASSURANCE
  - VERIFIABILITY OF REQUIREMENTS
  - DESIGNED-IN VERIFIABILITY
  - TEST AND VERIFICATION MATRIX AND PLAN



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DEVELOPMENT OF MISSION SCENARIOS IS BASED UPON THE GUIDELINES SHOWN IN THE FOLLOWING CHART AS WELL AS THE LIST OF RESEARCH PRIORITIES DERIVED FROM THE HILCHEY MEMORANDUM DATED OCTOBER 12, 1983, THE AMES RESEARCH CENTER REPORT "LIFE SCIENCES RESEARCH AND THE SCIENCE AND APPLICATIONS SPACE PLATFORM", AND "EXPERIMENTS DERIVED FROM THE 1982 LIFE SCIENCES WORKSHOPS." EXAMPLES OF THE MISSION SCENARIOS DEVELOPED USING THESE CRITERIA ARE PRESENTED IN THE NEXT EIGHT PAGES.

GUIDELINES USED FOR ASSEMBLING A MISSION SCENARIO

- LIMIT THE NUMBER OF SPECIES
- MAXIMUM USE OF EACH SPECIMEN: DATA OR SAMPLES TO MANY EXPERIMENTS
- GROUP EXPERIMENTS WITH REQUIREMENTS FOR SPECIALIZED EQUIPMENT OR PROCEDURES
- GROUP EXPERIMENTS WITH SIMILAR TIMELINES
- INCLUDE PLANT EXPERIMENTS IN EACH MISSION

LIFE SCIENCES MISSION SCENARIO A

EXPERIMENTS:	BL1A	BONE LOSS IN RATS
	BL4	BONE LOSS IN RATS USING ^{40}CA
	ML1A	MUSCLE LOSS IN RATS
	VP1	STRUCTURAL CHANGES IN LABYRINTH OF RATS
	PC 1	PLANT GROWTH
	PC 3	PLANT GROWTH/CELSS APPLICATION

ANIMAL SPECIMENS: 90 MATURE MALE WHITE RATS, 400-600 GRAMS

(45 AT STATION GRAVITY)

(45 AT 1-G ON CENTRIFUGE)

MAINTAINED IN STANDARD RODENT HOLDING FACILITY

SACRIFICE SCHEDULE: 6 FROM EACH GROUP (0-G AND 1-G) AT 2, 10, 20, 30, 50, AND 85 DAYS

REMAINING 9 ANIMALS FROM EACH GROUP RETURNED TO GROUND AT 90 DAYS, TO FOLLOW READAPTATION TO 1-G

PROCEDURES:

ALL LIVE ANIMALS WEIGHED EVERY 7 DAYS. ALL LIVE ANIMALS X-RAYED APPROX. EVERY 14 DAYS; X-RAYS DEVELOPED, DIGITIZED, AND DATA DOWNLINKED. INCISOR TEETH MEASURED APPROX. EVERY 7 DAYS TO DETERMINE ERUPTION RATE. TOTAL URINE AND FECES COLLECTED FOR EACH RAT IN 7-DAY PORTIONS, FOR STABLE CALCIUM ISOTOPE ANALYSIS AFTER RETURN. AT SACRIFICE, BONES DISSECTED OUT, WEIGHED, AND PRESERVED FOR HISTOLOGY AND MECHANICAL STRENGTH TEST; JAW FOR OSTEOBLAST DIFFERENTIATION; JOINTS AND KIDNEYS FOR CALCIUM DEPOSITS. MUSCLES DISSECTED, WEIGHED, AND PRESERVED FOR STRENGTH TEST, CHEMICAL AND ENZYMATIC ANALYSIS, AND HISTOLOGY. VESTIBULAR ORGANS OF THE HEAD REMOVED AND PRESERVED. ALL THE OTHER TISSUES WILL BE AVAILABLE FOR MANY ADDITIONAL STUDIES

EQUIPMENT:

- RODENT HOLDING FACILITY
- RODENT HOLDING FACILITY ON 1-G CENTRIFUGE
- CAGE WASHER
- FOOD, WATER
- SURGICAL WORKBENCH
- MASS MEASUREMENT DEVICE
- SACRIFICE KIT
- BLOOD COLLECTION KIT
- SMALL ANIMAL X-RAY
- DISSECTING MICROSCOPE
- MUSCLE TENSIOMETER
- LAB CENTRIFUGE
- FREEZER
- CHEMICALS
- VIALS
- X-RAY DEVELOPER
- X-RAY DIGITIZER
- WASTE STORAGE

PLANT SPECIMENS: APPROX. 25 SEEDS EACH OF ARABIDOPSIS, CARROT, PINE, AND BEAN IN A PLANT GROWTH UNIT. APPROX. 20 SEEDS EACH OF RADISH AND LETTUCE IN A SECOND PLANT GROWTH UNIT

PROCEDURE: WET AN ALIQUOT OF EACH TYPE OF SEED WITH NUTRIENT SOLUTION AT 5 DAY INTERVALS. MAINTAIN GROWTH CONDITIONS. RETURN ALL PLANTS LIVE TO GROUND FOR STUDY

EQUIPMENT: PLANT GROWTH UNITS
NUTRIENT SOLUTIONS
VIDEO CAMERA, DOWNLINKED
PHOTO CAMERA

LIFE SCIENCES MISSION SCENARIO B

EXPERIMENTS:	ML1B	NITROGEN BALANCE AND MUSCLE LOSS IN SMALL PRIMATES
	FE1B	FLUID AND ELECTROLYTE BALANCE IN SMALL PRIMATES
	MB1B	METABOLIC BALANCE IN THE SMALL PRIMATE
	MB5	RESPIRATORY GAS EXCHANGE IN SMALL PRIMATES
	MB7	GLUCOSE TOLERANCE AND METABOLITES IN SMALL PRIMATES

THE ABOVE EXPERIMENTS ON SQUIRREL MONKEYS REQUIRE THE USE OF METABOLIC CAGES

	PC8	PLANT GROWTH - MULTIPLE GENERATIONS

MISSION DURATION: 90 DAYS

LIFE SCIENCES MISSION SCENARIO C

EXPERIMENTS:

CV1	CARDIOVASCULAR FUNCTION IN RESTRAINED RHESUS MONKEYS
FE2	FLUID AND ELECTROLYTE BALANCE IN RESTRAINED RHESUS MONKEYS
VP2C	VESTIBULAR FUNCTION IN RESTRAINED RHESUS MONKEYS
PC5	STUDY OF CHLORELLA

MISSION DURATION: 30 DAYS

LIFE SCIENCES MISSION SCENARIO D

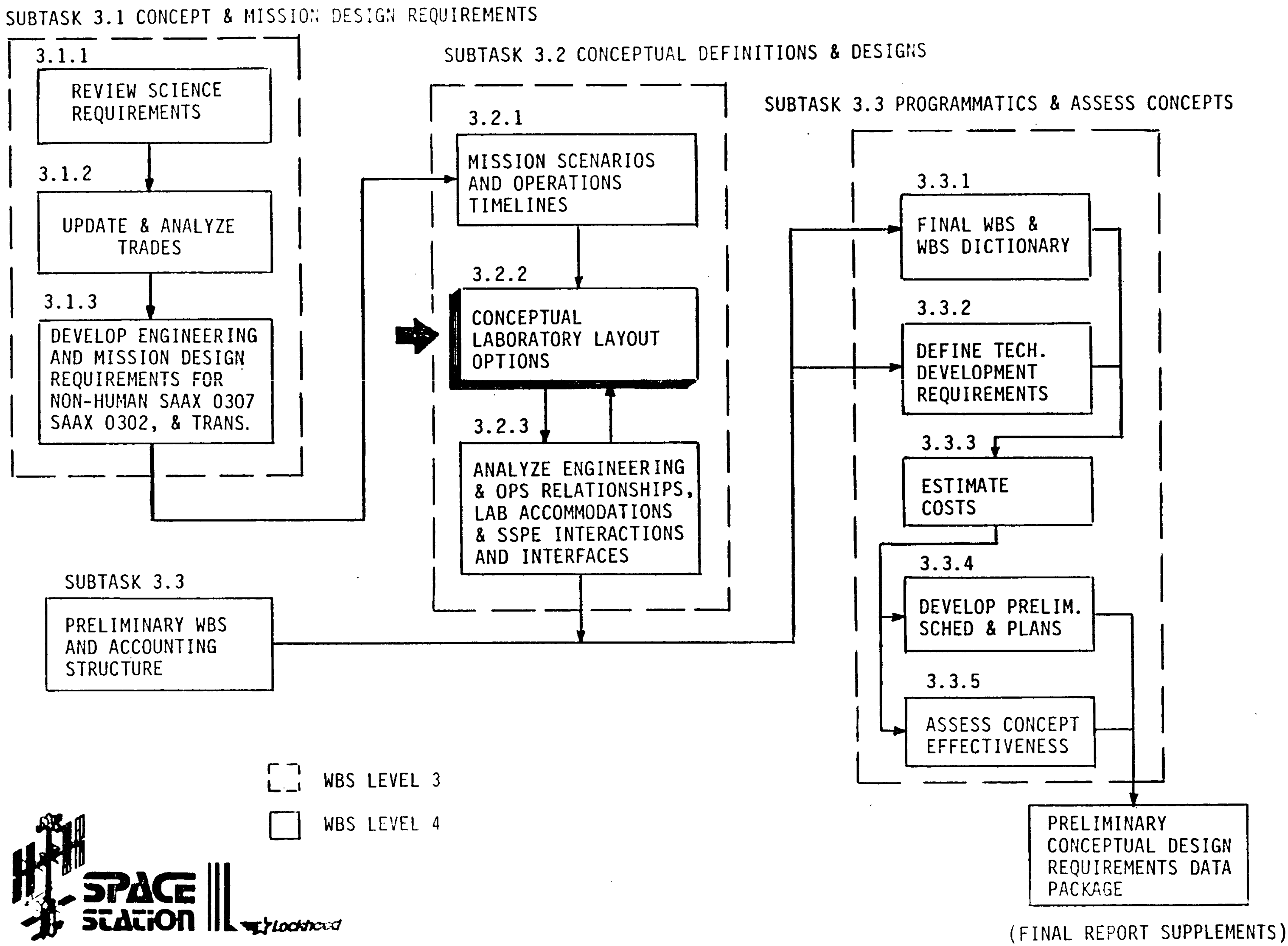
EXPERIMENTS:

- ML1A NITROGEN BALANCE AND MUSCLE LOSS IN RATS
- FE1A FLUID AND ELECTROLYTE BALANCE IN RATS
- MB1A METABOLIC BALANCE IN THE RAT
- MB4 RESPIRATORY GAS EXCHANGE IN THE RAT

THE ABOVE EXPERIMENTS REQUIRE THE USE OF METABOLIC CAGES FOR RATS

- RD2C EMBRYONIC DEVELOPMENT IN TERRESTRIALLY IMPREGNATED MICE
- PC4A PLANT GROWTH AND NUTRIENT RECYCLING

MISSION DURATION: 90 DAYS



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EIGHT MODULE ARRANGEMENT LAYOUTS ARE PRESENTED WITH NON-HUMAN EQUIPMENT OUTFITTING VOLUMES EQUAL TO EITHER 1/2 OF A MODULE OR A FULL MODULE. THE OPTIONS ARE BASED ON THE USE OF A 2.75M DIAMETER CENTRIFUGE COMBINED WITH A HORIZONTAL OR VERTICAL LAYOUT OR A 3.75M DIAMETER DOUBLE ROTOR CENTRIFUGE COMBINED WITH A HORIZONTAL OR VERTICAL LAYOUT.

MODULE ARRANGMENT LAYOUTS

1/2 MODULE → 2.75 M DIA CENTRIFUGE → HORIZONTAL

FULL MODULE → FULL DIAMETER CENTRIFUGE → VERTICAL

- FOUR OPTIONS FOR 1/2 MODULE
- FOUR OPTIONS FOR FULL MODULE

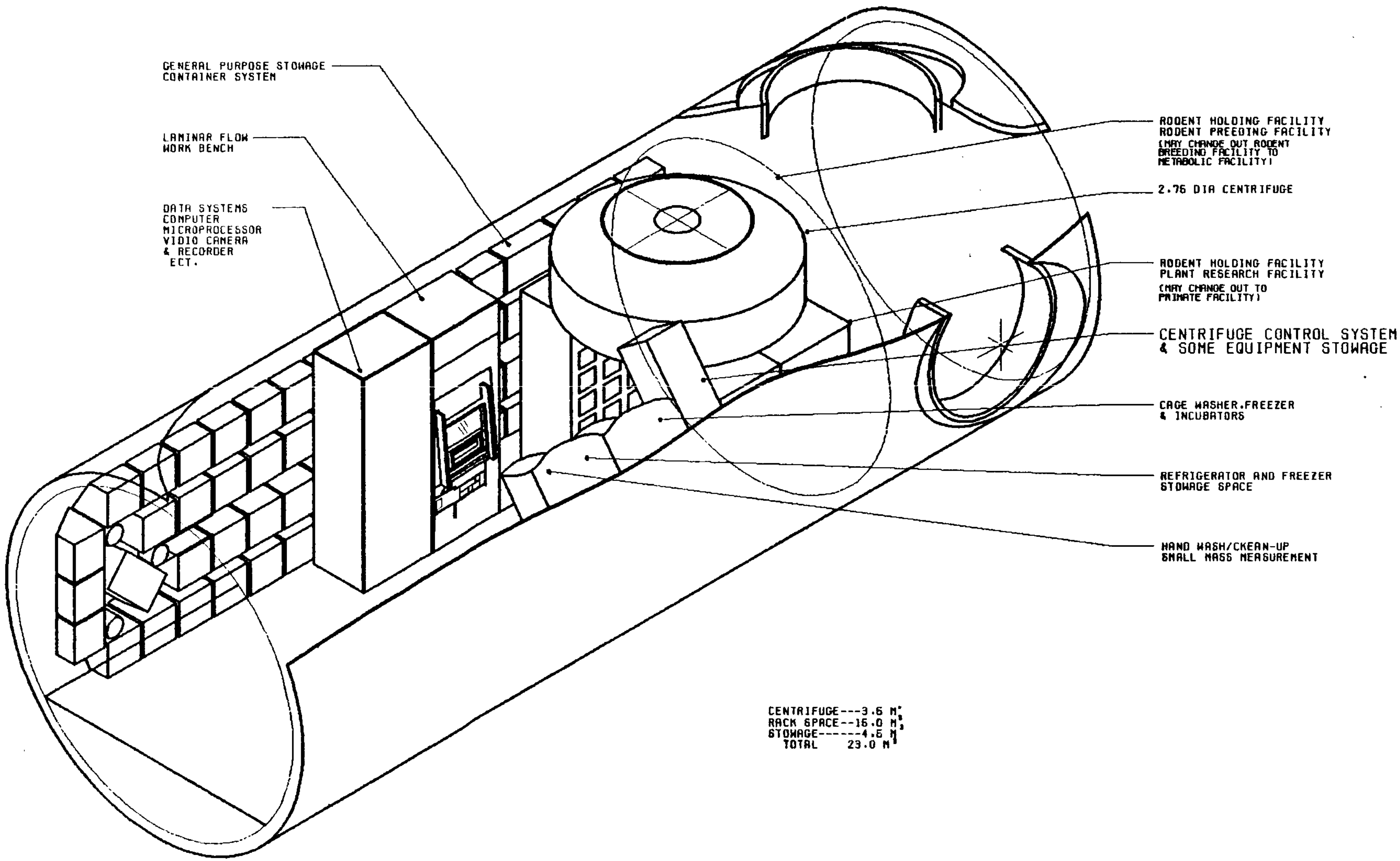
  WITH CHANGE-OUT BETWEEN SECOND CENTRIFUGE
  AND MINI-LAB CONSIDERED FOR FULL MODULE

ELECTRICAL INTERFACES (1/2 MODULE, HORIZ., 2.75 M DIA)

SECONDARY STRUCTURE

STRUCTURAL CONSIDERATIONS

THE 1/2 MODULE HORIZONTAL LAYOUT WITH 2.75M CENTRIFUGE UTILIZES 23.0M^3 OF VOLUME APPORTIONED AS FOLLOWS: 3.5M^3 FOR THE CENTRIFUGE, 15.0M^3 OF RACK VOLUME AND 4.5M^3 OF STOWAGE VOLUME.



SPACE STATION

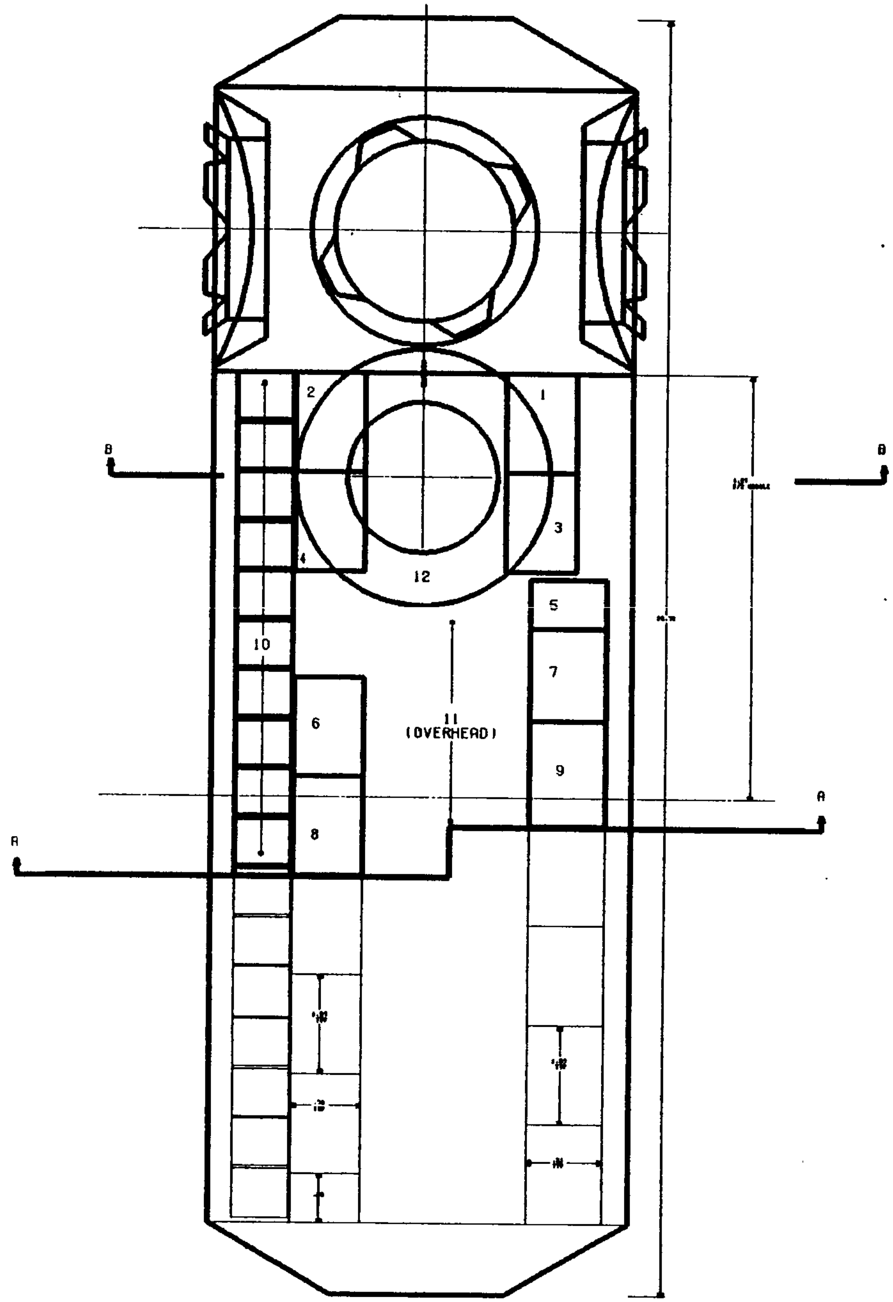
1/2 LAB 13.7 M MODULE LAYOUT

Lockheed

THE 23.0M^3 EQUIPMENT, STOWAGE, AND RACK VOLUME ACCOMMODATES 20.0M^3 OF ANIMAL AND PLANT RESEARCH EQUIPMENT AND 3.0M^3 OF SHARED HUMAN AND PLANT AND ANIMAL RESEARCH EQUIPMENT.

NON-HUMAN LAB EQUIPMENT

RACK NUMBER	RACK VOLUME (CUBIC M)	USER DESIGNATION	EQUIPMENT
1	1.5	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52), SPECIMEN FOOD AND WATER (#96,97), STORAGE.
2	1.5	NON-HUMAN	RODENT BREEDING HOLDING FACILITY (#53).
3	1.5	NON-HUMAN	PLANT RESEARCH FACILITY (#81).
4	1.6	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52).
5	1	NON-HUMAN	CENTRIFUGE CONTROLS, PH,ION ANALYZER (#208), OSCILLOSCOPE (#207), MICROSCOPES (#).
6	2	NON-HUMAN	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(#124), SPECTROPHOTOMETER (#206), MASS SPEC/GAS ANALYZER (#163), ANIMAL MONITORING (#203).
7	2	NON-HUMAN	CAGE WASHER (#98). INCUBATOR CO2(#202), EGG INCUBATOR (#76), CELSS (#90), FREEZER (#45).
8	2	1 H, 1 N-H	DATA SYSTEM (#33-36), COMPUTER (#61), STRIP CHART RECORDER (#162), MICROPROCESSOR (#209), VIDEO CAMERA AND RECORDER (#141).
9	2	.5 H, 1.5N-H	HAND WASHER (#100). REFRIGERATOR/FREEZERS (#44,45), ENVIRONMENTAL MONITOR (#142), PHYSIOLOGICAL AMPLIFIER (#143), DOSIMETER (#126), SMALL MASS MEASUREMENT (#112).
10	2.5	NON-HUMAN	SOLIDS WASTE STORAGE (#93), STORAGE.
11	2	NON-HUMAN	LIQUID WASTE STORAGE (#92).
12	3.5	NON-HUMAN	2.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE (#63).
	21.5 1.6	NON-HUMAN HUMAN	TOTAL VOLUME



1/2 LAB EQUIPMENT

SPACE STATION

Lockheed

THE FULL MODULE HORIZONTAL LAYOUT DEDICATED TO ANIMAL-PLANT RESEARCH CONTAINS TWO 2.75M DIAMETER CENTRIFUGES AND UTILIZES 44.2M^3 OF VOLUME APPORTIONED AS FOLLOWS: 2 CENTRIFUGES 7.0M^3, RACK SPACE 27.7M^3 AND STOWAGE SPACE 9.5M^3.

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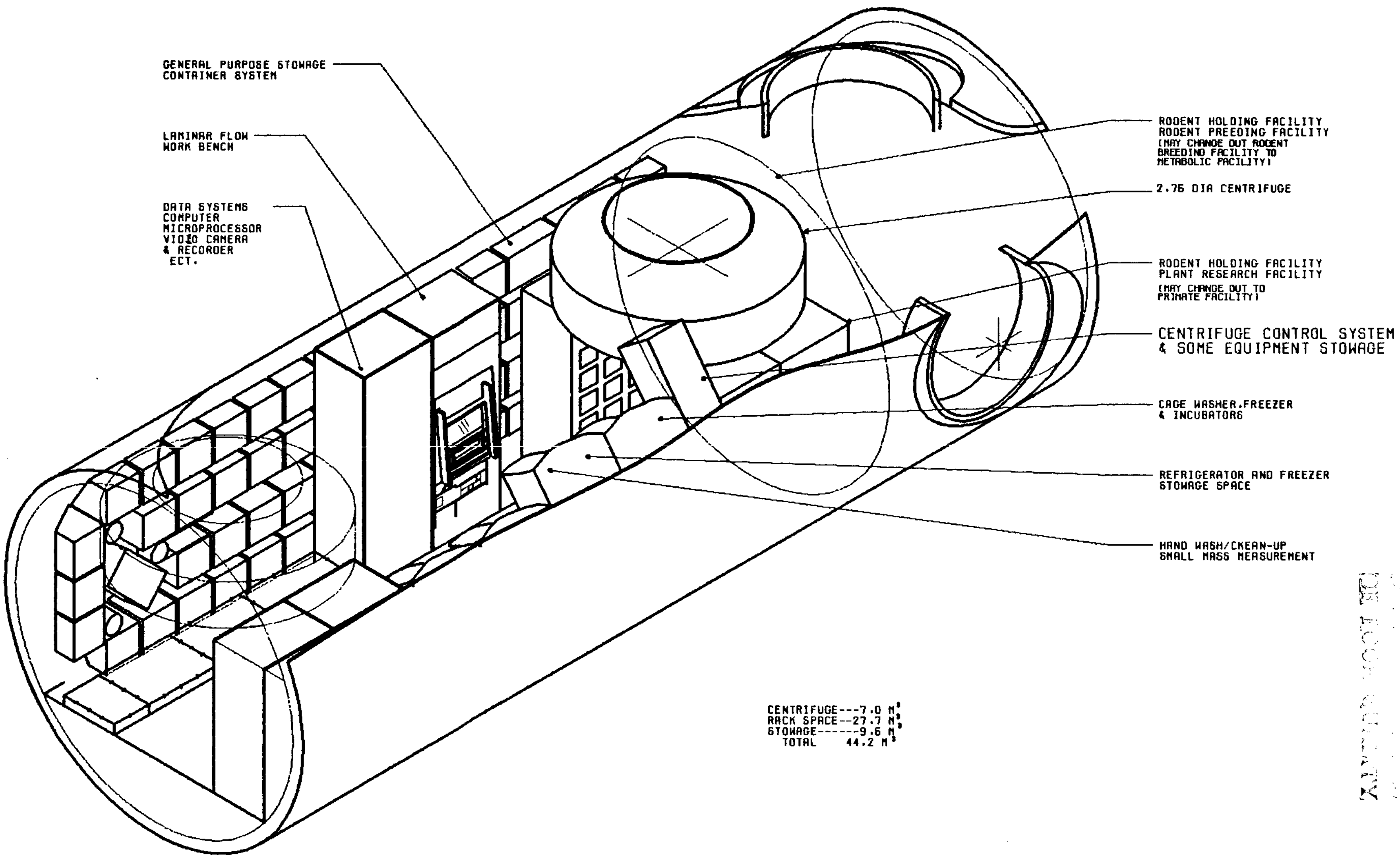


SPACE STATION

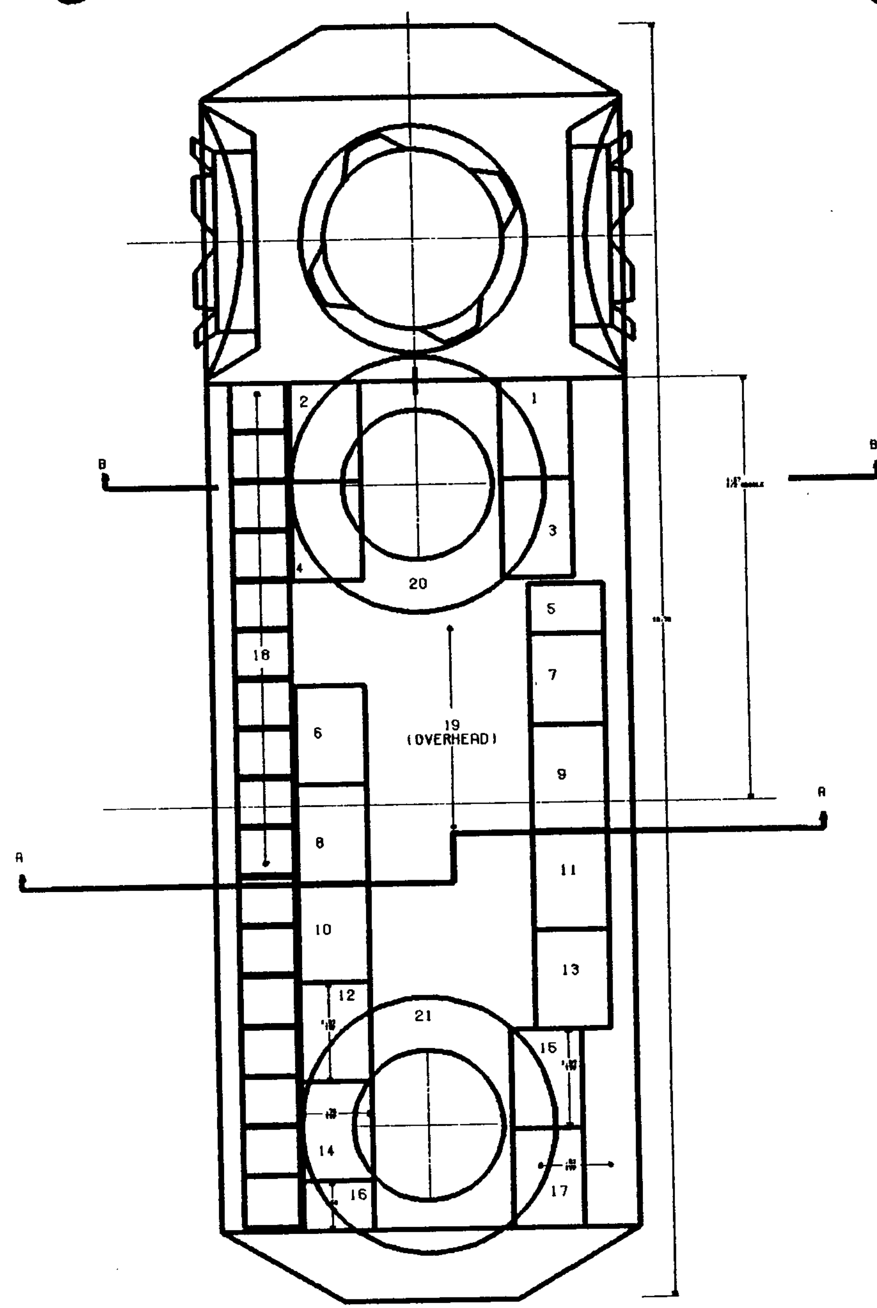
FULL LAB 13.7 M MODULE LAYOUT

Lockheed

THE ENTIRE 44.2M^3 EQUIPMENT VOLUME IS DEDICATED TO ANIMAL-PLANT EXPERIMENTS IN THE FULL LAB HORIZONTAL CONFIGURATION.

NON-HUMAN LAB EQUIPMENT

RACK NUMBER	RACK VOLUME (CUBIC M)	USER DESIGNATION	EQUIPMENT
1	1.5	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52), SPECIMEN FOOD AND WATER (#96,97), STORAGE.
2	1.5	NON-HUMAN	RODENT BREEDING HOLDING FACILITY (#53).
3	1.5	NON-HUMAN	PLANT RESEARCH FACILITY (#81).
4	1.5	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52).
5	1	NON-HUMAN	CENTRIFUGE CONTROLS, PH.ION ANALYZER (#208), OSCILLOSCOPE(#207), MICROSCOPES (#).
6	2	NON-HUMAN	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(#124), SPECTROPHOTOMETER (#206), MASS SPEC/GAS ANALYZER (#163), ANIMAL MONITORING (#203).
7	2	NON-HUMAN	CAGE WASHER (#98). INCUBATOR CO2(#202), EGG INCUBATOR (#76), CELSS (#90), FREEZER (#45), LABORATORY CENTRIFUGE(#28)
8	2	1 H, 1 N-H	DATA SYSTEM (#33-36), COMPUTER (#61), STRIP CHART RECORDER (#162), MICROPROCESSOR (#209), VIDEO CAMERA AND RECORDER (#141).
9	2	.5 H,1.5N-H	HAND WASHER (#100). REFRIGERATOR/FREEZERS (#44,45), ENVIRONMENTAL MONITOR (#142), PHYSIOLOGICAL AMPLIFIER (#143), DOSIMETER (#126), SMALL MASS MEASUREMENT (#112).
10	2	.5 H,1.5N-H	STORAGE, PRIMATE RESTRAINT KIT (#205).
11	2	.5 H,1.5N-H	2 REFRIGERATOR/FREEZERS (#44), FREEZER (#45).
12	1.5	.5 H,1.5N-H	METABOLIC FACILITY (#).
13	2	.5 H,1.5N-H	STORAGE
14	1.5	.5 H,1.5N-H	ADDITIONAL PLANT RESEARCH FACILITY (#81)
15	1.5	.5 H,1.5N-H	ADDITIONAL RODENT HOLDING FACILITY (#52).
16	.7	.5 H,1.5N-H	ADDITIONAL PLANT RESEARCH FACILITY (#81)
17	1.5	.5 H,1.5N-H	LARGE PRIMATE HOLDING FACILITY (#58), SPECIMEN FOOD AND WATER (#96,97).
18	5.5	NON-HUMAN	SOLIDS WASTE STORAGE (#93), STORAGE.
19	4	NON-HUMAN	LIQUID WASTE STORAGE (#92).
20	3.5	NON-HUMAN	2.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE (#63).
21	3.5	NON-HUMAN	2.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE (#63).
	44.2	NON-HUMAN	TOTAL VOLUME

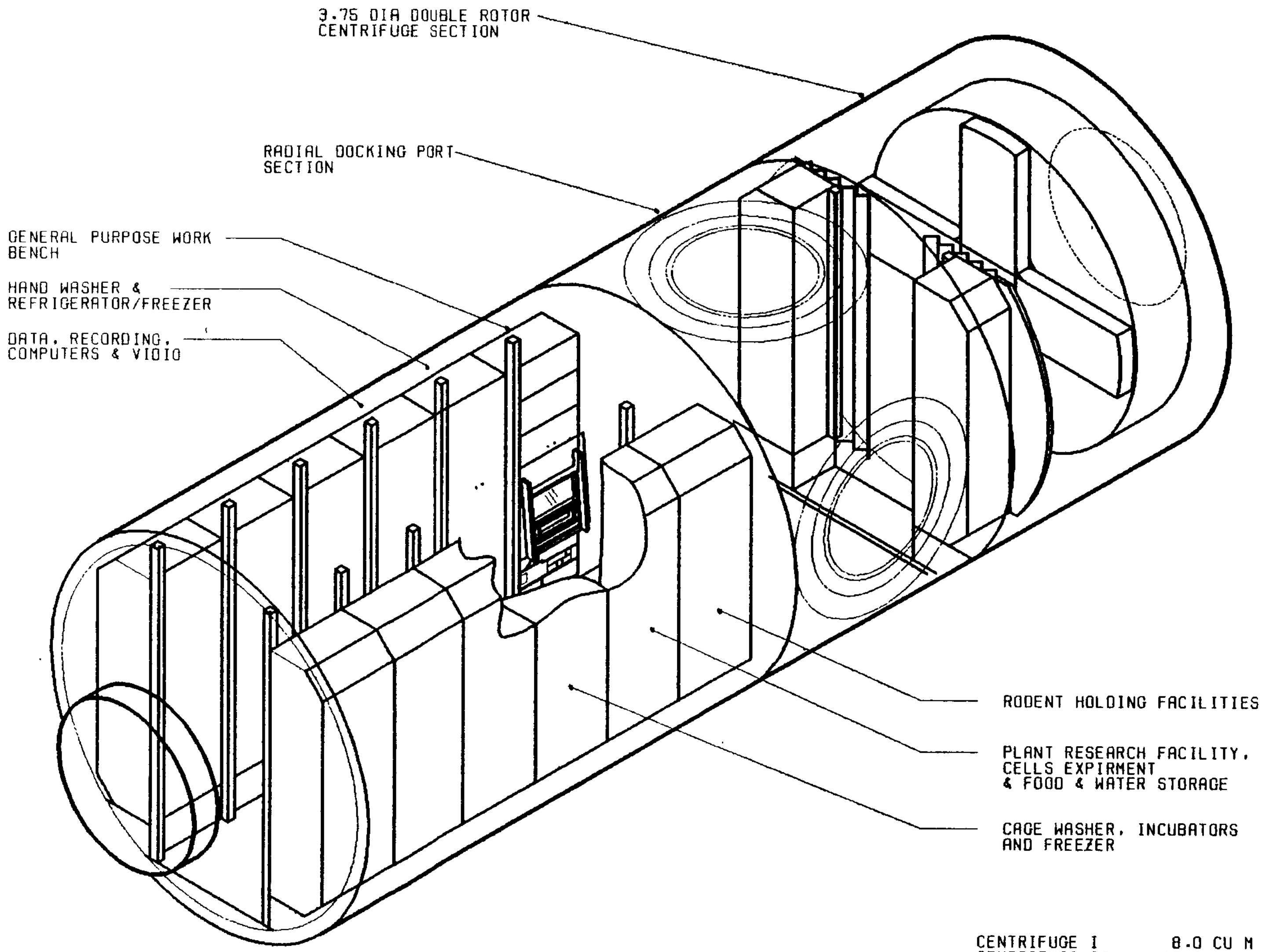


SPACE STATION

FULL LAB EQUIPMENT

Lockheed

THE MODIFIED RACETRACK 1/2 MODULE LAYOUT HAS RADIAL DOCKING PORTS LOCATED TOWARD THE MODULE LENGTH MID-POINT AND CONTAINS THE 3.75M DOUBLE CENTRIFUGE. $37.2M^3$ OF VOLUME IS APPORTIONED AS FOLLOWS: THE CENTRIFUGE UTILIZES $18M^3$, RACK VOLUME $15.4M^3$, LIQUID STOWAGE $2.0M^3$, AND DRY STOWAGE $1.8M^3$.



CENTRIFUGE I	8.0 CU M
CENTRIFUGE II	10.0 CU M
RACK (2 @ 1.1)	2.2 CU M
RACK (6 @ 2.2)	13.2 CU M
LIQUID STOWAGE	2.0 CU M
STOWAGE (12 @.15)	1.8 CU M
TOTAL	37.2 CU M

SPACE STATION

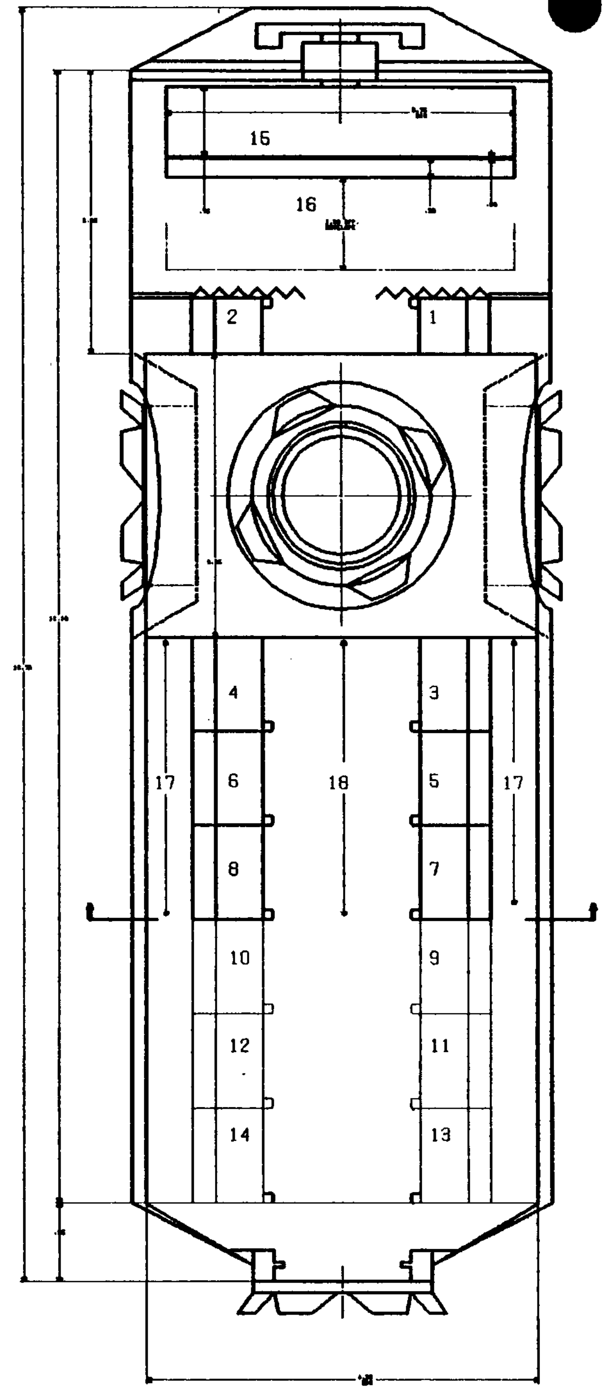
1/2 LAB LAYOUT IN MODIFIED RACETRACK (MRT) PATTERN

Lockheed

A TOTAL OF 13.9M^3 OF DEDICATED ANIMAL-PLANT RESEARCH EQUIPMENT AND 22.4M^3 OF SHARED HUMAN AND ANIMAL/PLANT RESEARCH EQUIPMENT CAN BE ACCOMMODATED IN THE 1/2 LAB MODIFIED RACETRACK HORIZONTAL CONFIGURATION.

NON-HUMAN LAB EQUIPMENT

RACK NUMBER	VOLUME (CUBIC M)	USER DESIGNATION	EQUIPMENT
1	1.1	6 H, .5 N-H	CENTRIFUGE ANCELLARARY EQUIP STORAGE (#63)
2	1.1	5 H, .6 N-H	CENTRIFUGE CONTROL SYSTEM (#63)
3	2.2	NON-HUMAN	RODENT STANDARD HOLDING FACILITY 2 UNITS (#52).
4	2.2	NON-HUMAN	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(#124), SPECTROPHOTOMETER (#206), MASS SPEC/GAS ANALYZER (#163), ANIMAL MONITORING (#203).
5	2.2	NON-HUMAN	PLANT RESEARCH FACILITY (#81), CELLS (# 90) PH.ION ANALYZER (#208), OSCILLOSCOPE (#207), MICROSCOPES (#) FOOD AND WATER (#96,97), STORAGE.
6	2.2	NON-HUMAN	HAND WASHER (#100). REFRIGERATOR/FREEZERS (#44,45), ENVIRONMENTAL MONITOR (#142), PHYSIOLOGICAL AMPLIFIER (#143), DOSIMETER (#126), SMALL MASS MEASUREMENT (#112).
7	2.2	NON-HUMAN	CAGE WASHER (#98). INCUBATOR CO2(#202), EGG INCUBATOR (#76). FREEZER (#46).
8	2.2	1 H, 1 N-H	DATA SYSTEM (#33-36), COMPUTER (#51), STRIP CHART RECORDER (#162), MICROPROCESSOR (#209), VIDEO CAMERA AND RECORDER (#141).
15	8	NON-HUMAN	3.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE I (#63).
16	10	9 H, 1 N-H	3.75 M DIA RESEARCH CENTRIFUGE II (#63).
17	1.8	NON-HUMAN	SOLIDS WASTE STORAGE (#93), STORAGE.
18	2	NON-HUMAN	LIQUID WASTE STORAGE (#92).
	24.5 11.7	NON-HUMAN HUMAN	TOTAL VOLUME



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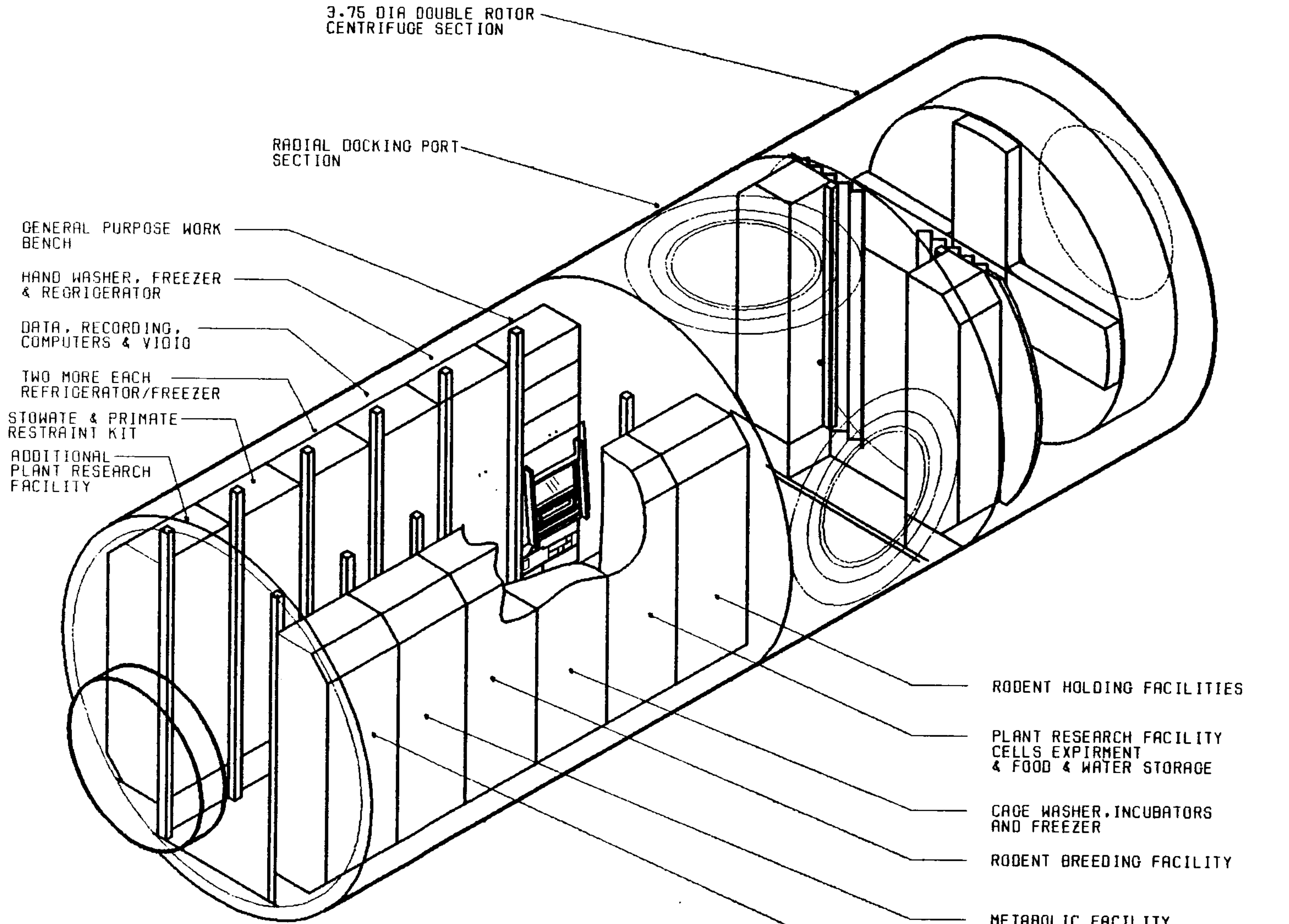
SPACE STATION

EQUIPMENT - 1/2 LAB - MRT

Lockheed

THE FULL LAB MODIFIED RACETRACK HORIZONTAL LAYOUT CONTAINING THE 3.75M CENTRIFUGE UTILIZES 54.2M^3 APPORTIONED AS FOLLOWS: CENTRIFUGE 18.0M^3, RACK VOLUME 28.6M^3, LIQUID STOWAGE 4.0M^3, AND DRY STOWAGE 3.6M^3.



CENTRIFUGE I	8.0 CU M
CENTRIFUGE II	10.0 CU M
RACK (2 @ 1.1)	2.2 CU M
RACK (12 @ 2.2)	26.4 CU M
LIQUID STOWAGE	4.0 CU M
STOWAGE (24 @.15)	3.6 CU M
TOTAL	54.2 CU M

SPACE STATION

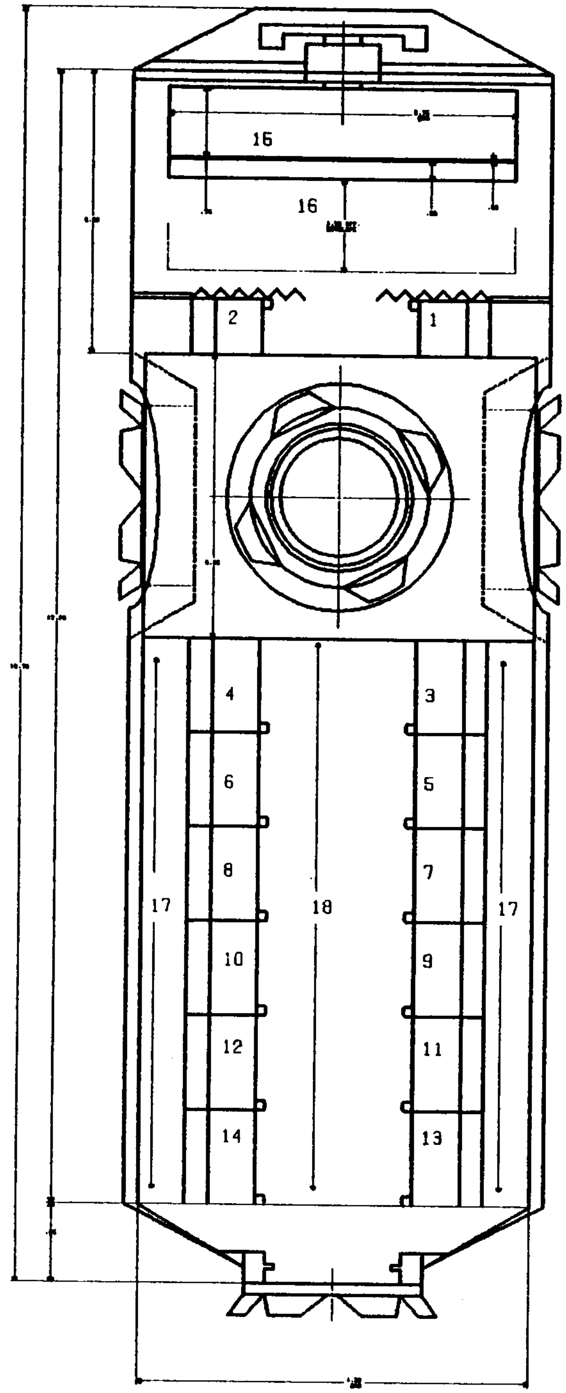
EQUIPMENT - FULL LAB - MRT

Lockheed

THE DEDICATED FULL MODIFIED RACETRACK LAYOUT USES 53.2M^3 FOR ANIMAL-PLANT EXPERIMENTS AND EQUIPMENT.

NON-HUMAN LAB EQUIPMENT

RACK NUMBER	RACK VOLUME (CUBIC M)	USER DESIGNATION	EQUIPMENT
1	1.1	NON-HUMAN	CENTRIFUGE ANCELLARARY EQUIP STORAGE (#63)
2	1.1	NON-HUMAN	CENTRIFUGE CONTROL SYSTEM (#63)
3	2.2	NON-HUMAN	RODENT STANDARD HOLDING FACILITY 2 UNITS (#62)
4	2.2	NON-HUMAN	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(#124), SPECTROPHOTOMETER (#206), MASS SPEC/GAS ANALYZER (#163), ANIMAL MONITORING (#203).
5	2.2	NON-HUMAN	PLANT RESEARCH FACILITY (#81), CELLS (# 90) PH.ION ANALYZER (#208), OSCILLOSCOPE (#207), MICROSCOPES (#) FOOD AND WATER (#96,97), STORAGE.
6	2.2	NON-HUMAN	HAND WASHER (#100). REFRIGERATOR/FREEZERS (#44,45), ENVIRONMENTAL MONITOR (#142), PHYSIOLOGICAL AMPLIFIER (#143), DOSIMETER (#126), SMALL MASS MEASUREMENT (#112)
7	2.2	NON-HUMAN	CAGE WASHER (#98). INCUBATOR CO2(#202), EGG INCUBATOR (#76), FREEZER (#45).
8	2.2	NON- HUMAN	DATA SYSTEM (#33-36), COMPUTER (#61), STRIP CHART RECORDER (#162), MICROPROCESSOR (#209), VIDEO CAMERA AND RECORDER (#141).
9	2.2	NON-HUMANH	RODENT BREEDING HOLDING FACILITY (#53).
10	2.2	NON-HUMAN	2 REFRIGERATOR/FREEZERS (#44), FREEZER (#45).
11	2.2	NON-HUMAN	METABOLIC FACILITY (#).ADDITIONAL RODENT HOLDING FACILITY (#62).
12	2.2	NON-HUMAN	STORAGE, PRIMATE RESTRAINT KIT (#205).
13	2.2	NON-HUMAN	LARGE PRIMATE HOLDING FACILITY (#58), SPECIMEN FOOD AND WATER (#96,97).
14	2.2	NON-HUMAN	ADDITIONAL PLANT RESEARCH FACILITY (#81)
15	6	NON-HUMAN	3.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE I (#63).
16	10	NON-HUMAN	3.75 M DIA RESEARCH CENTRIFUGE II (#63).
17	3.6	NON-HUMAN	SOLIDS WASTE STORAGE (#93), STORAGE.
18	4	NON-HUMAN	LIQUID WASTE STORAGE (#92).
	53.2	NON-HUMAN	TOTAL VOLUME

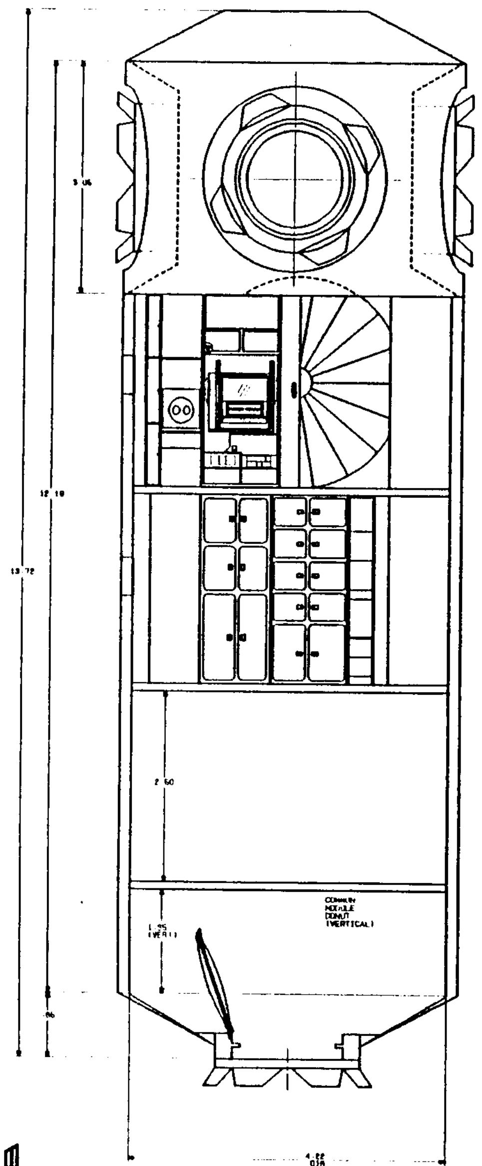


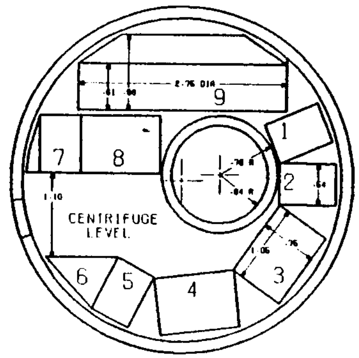
SPACE STATION

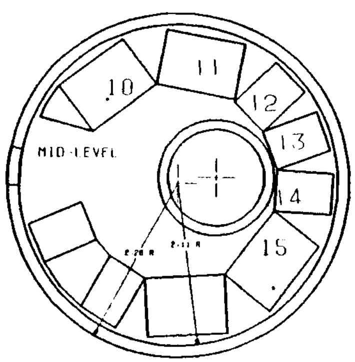
FULL LAB LAYOUT - MRT

Lockheed

THE 1/2 MODULE VERTICAL LAYOUT WITH 2.75 M CENTRIFUGE UTILIZES 23.0M^3 OF INTERNAL VOLUME ON TWO LEVELS APPORTIONED AS FOLLOWS: 3.5M^3 FOR CENTRIFUGE, 15.0M^3 RACK VOLUME, AND 4.5M^3 STOWAGE. NON-HUMAN RESEARCH EQUIPMENT UTILIZES 20.0M^3 AND SHARED PLANT/ANIMAL AND HUMAN RESEARCH 3.0M^3 OF THE TOTAL VOLUME, RESPECTIVELY.

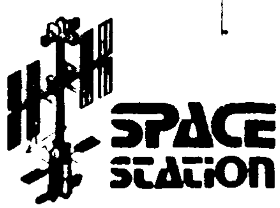






NON-HUMAN LAB EQUIPMENT

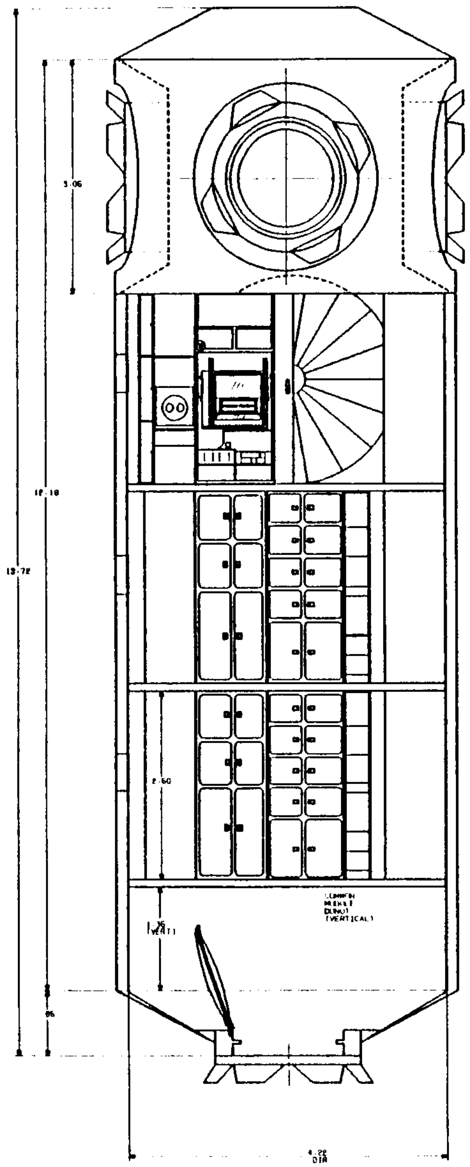
RACK NUMBER	RACK VOLUME (CUBIC M)	USER DESIGNATION	EQUIPMENT
1	1	NON-HUMAN	CENTRIFUGE CONTROLS (#63). STORAGE.
2	1	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52).
3	2	NON-HUMAN	CAGE WASHER (•98), SPECIMEN FOOD AND WATER (•96,97), STORAGE.
4	2	NON-HUMAN	RODENT BREEDING HOLDING FACILITY (#53).
5	1	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52A).
6	0.5	NON-HUMAN	STORAGE, PH/ION ANALYZER (#208), OSCILLOSCOPE (•207), MICROSCOPES (•).
7	1	NON-HUMAN	HAND WASHER (#100).
8	2	NON-HUMAN	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(•124), SPECTROPHOTOMETER (•206), MASS SPEC/GAS ANALYZER (•189), ANIMAL MONITORING (•203).
9	3.5	NON-HUMAN	2.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE (#63).
10	2	NON-HUMAN	LIQUID WASTE STORAGE (•92).
11	2	NON-HUMAN	SOLIDS WASTE STORAGE (•93).
12	1	NON-HUMAN	INCUBATOR CO2(•202), EGG INCUBATOR (•78), CELSS (•80), FREEZER(•45A),LABORATORY CENTRIFUGE (•28).
13	1	NON-HUMAN	PLANT RESEARCH FACILITY (•81).
14	1	.5 H, .5N-H	REFRIGERATOR/FREEZERS (•44,45), ENVIRONMENTAL MONITOR (•142), PHYSIOLOGICAL AMPLIFIER (•143), DOSIMETER (•125), SMALL MASS MEASUREMENT (•112).
16	2	1 H, 1 N-H	DATA SYSTEM (•33-36), COMPUTER (•51), STRIP CHART RECORDER (•162), MICROPROCESSOR (•209), VIDEO CAMERA AND RECORDER (•141).
	21.5 1.5	NON-HUMAN HUMAN	TOTAL VOLUME

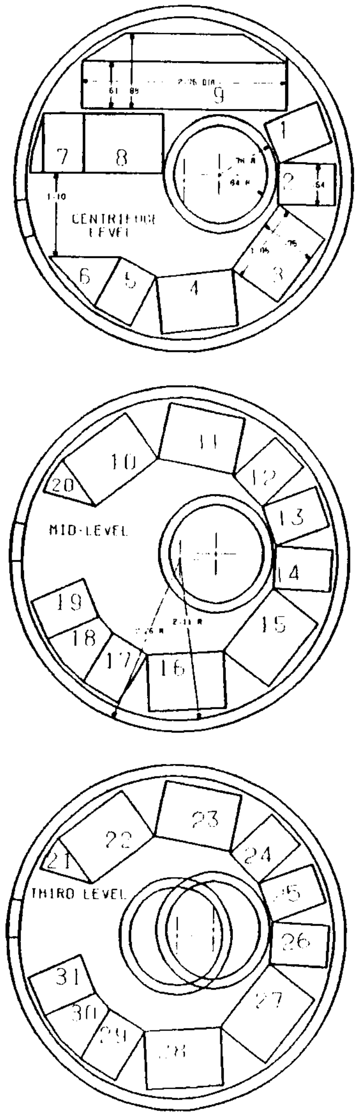


1/2 LAB - VERTICAL LAYOUT

Lockheed

THE FULL MODULE VERTICAL LAYOUT WITH 2.75M CENTRIFUGE DEDICATED TO ANIMAL-PLANT EXPERIMENTS UTILIZES 43.0M^3 OF WHICH 3.5M^3 IS CENTRIFUGE VOLUME, 22.5M^3 IS RACK VOLUME, 15.0M^3 IS DRY STOWAGE AND 2.0M^3 IS LIQUID STORAGE VOLUME.





NON-HUMAN LAB EQUIPMENT

RACK NUMBER	RACK VOLUME (CUBIC M)	EQUIPMENT
1	1	CENTRIFUGE CONTROLS (#63), STORAGE.
2	1	RODENT STANDARD HOLDING FACILITY (#52).
3	2	CAGE WASHER (•88), SPECIMEN FOOD AND WATER (•86,87), STORAGE.
4	2	RODENT BREEDING HOLDING FACILITY (#53).
5	1	RODENT STANDARD HOLDING FACILITY (#52A).
6	0.5	STORAGE, PH/ION ANALYZER (#208), OSCILLOSCOPE (•207), MICROSCOPES (•), PRIMATE KIT (•205).
7	1	HAND WASHER (#100).
8	2	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(•124), SPECTROPHOTOMETER (•206), MASS SPEC/GAS ANALYZER (•163), ANIMAL MONITORING (•203).
9	3.5	2.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE (#63).
10	2	LIQUID WASTE STORAGE (•82).
11	2	SOLIDS WASTE STORAGE (•93).
12	1	INCUBATOR CO2(•202), EGG INCUBATOR (•76), CELSS (•80), FREEZER (•45A),LABORATORY CENTRIFUGE(•28).
13	1	PLANT RESEARCH FACILITY (•81).
14	1	REFRIGERATOR/FREEZERS (•44, 45), ENVIRONMENTAL MONITOR (•142), PHYSIOLOGICAL AMPLIFIER (•143), DOSIMETER (•126), SMALL MASS MEASUREMENT (•112).
15	2	DATA SYSTEM (•33-36), COMPUTER (•51), STRIP CHART RECORDER (•162), MICROPROCESSOR (•209), VIDEO CAMERA AND RECORDER (•141).
	23	TOTAL VOLUME

NON-HUMAN LAB EQUIPMENT

RACK NUMBER	RACK VOLUME (CUBIC M)	EQUIPMENT
16	2	LARGE PRIMATE HOLDING FACILITY (•58), SPECIMEN FOOD AND WATER (•86A, 87A).
17	1	ADDITIONAL RODENT HOLDING FACILITY (•52B).
18	1	STORAGE.
19	1	METABOLIC FACILITY (•).
20	0.5	STORAGE.
21	0.5	STORAGE.
22	2	STORAGE.
23	2	STORAGE.
24	1	STORAGE.
25	1	STORAGE.
26	1	2 REFRIGERATOR/FREEZERS (•44A,B), FREEZER (•45B).
27	2	ADDITIONAL PLANT RESEARCH FACILITY (•81A).
28	2	STORAGE.
29	1	STORAGE.
30	1	STORAGE.
31	1	STORAGE.
	20	TOTAL VOLUME

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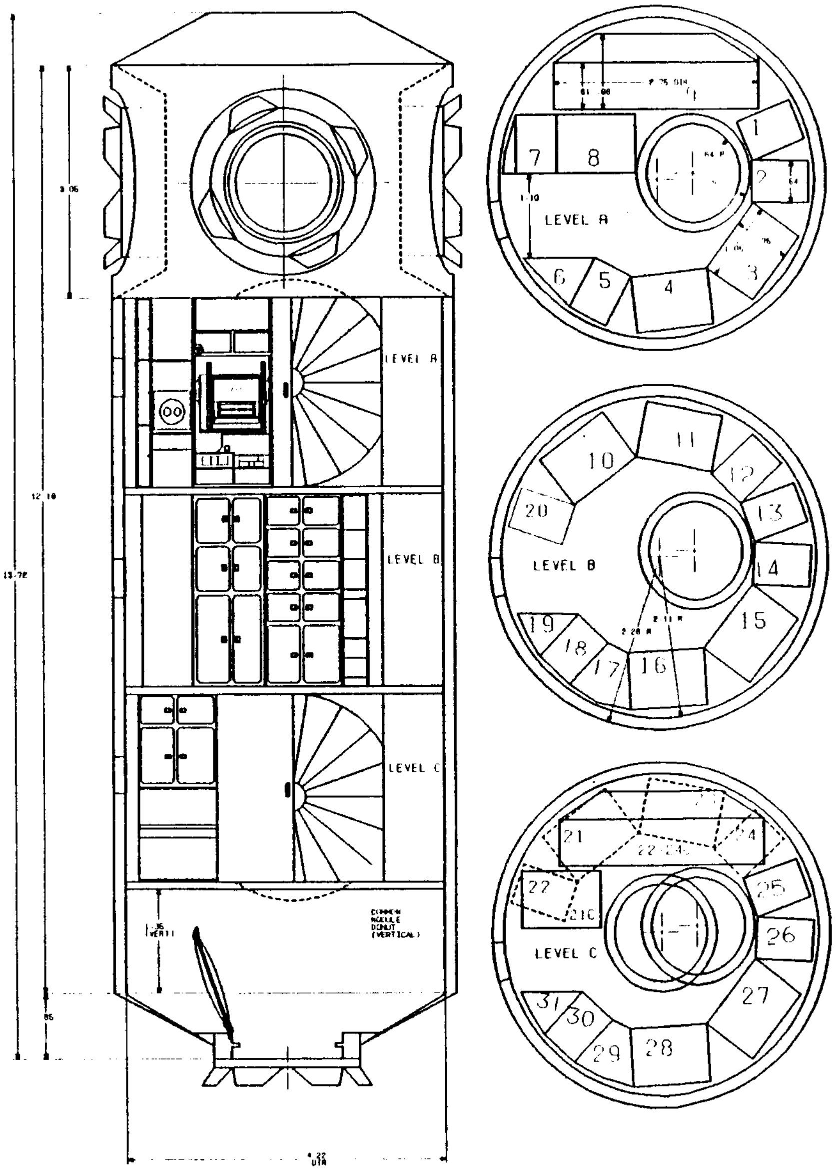
SPACE STATION

FULL LAB - VERTICAL ARRANGEMENT

Lockheed

IN THE FULL LAB WITH TWO 2.75M CENTRIFUGES AND MINILAB OPTIONS $6M^3$ OF RACKS MAY BE USED FOR EXPERIMENT SPECIFIC LAB EQUIPMENT OR A SECOND CENTRIFUGE WITH CONTROLS. IN THIS ARRANGEMENT 43.0 OF EQUIPMENT CAN BE ACCOMMODATED WITH DRY STOWAGE VOLUME REDUCED FROM $15.0M^3$ TO $10.5M^3$ AND AN ADDITIONAL $1.0M^3$ OF RACK VOLUME AVAILABLE.



NON-HUMAN LAB EQUIPMENT

RACK NUMBER	RACK VOLUME (CUBIC M)	EQUIPMENT
1	1	CENTRIFUGE CONTROLS(#63), STORAGE.
2	1	RODENT STANDARD HOLDING FACILITY (#52).
3	2	CAGE WASHER (•98), SPECIMEN FOOD AND WATER (•96,97), STORAGE.
4	2	RODENT BREEDING HOLDING FACILITY (#53).
5	1	RODENT STANDARD HOLDING FACILITY (#52A).
6	0.5	STORAGE. PH/ION ANALYZER (#208), OSCILLOSCOPE (•207), MICROSCOPES (•), PRIMATE KIT (•206).
7	1	HAND WASHER (#100).
8	2	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(•124), SPECTROPHOTOMETER (•206), MASS SPEC/GAS ANALYZER (•163), ANIMAL MONITORING (•203).
9	3.5	2.75 M DIA ARTIFICIAL GRAVITY CENTRIFUGE (#63).
10	2	LIQUID WASTE STORAGE (•82).
11	2	SOLIDS WASTE STORAGE (•83).
12	1	INCUBATOR CO2(•202), EGG INCUBATOR (•78), CELSS (•90), FREEZER (•45A),LABORATORY CENTRIFUGE(•28).
13	1	PLANT RESEARCH FACILITY (•81).
14	1	REFRIGERATOR/FREEZERS (•44,45), ENVIRONMENTAL MONITOR (•142), PHYSIOLOGICAL AMPLIFIER (•143), DOSIMETER (•126), SMALL MASS MEASUREMENT (•112).
15	2	DATA SYSTEM (•33-38), COMPUTER (•51), STRIP CHART RECORDER (•162), MICROPROCESSOR (•208), VIDEO CAMERA AND RECORDER (•141).
	23	TOTAL VOLUME

NON-HUMAN LAB EQUIPMENT

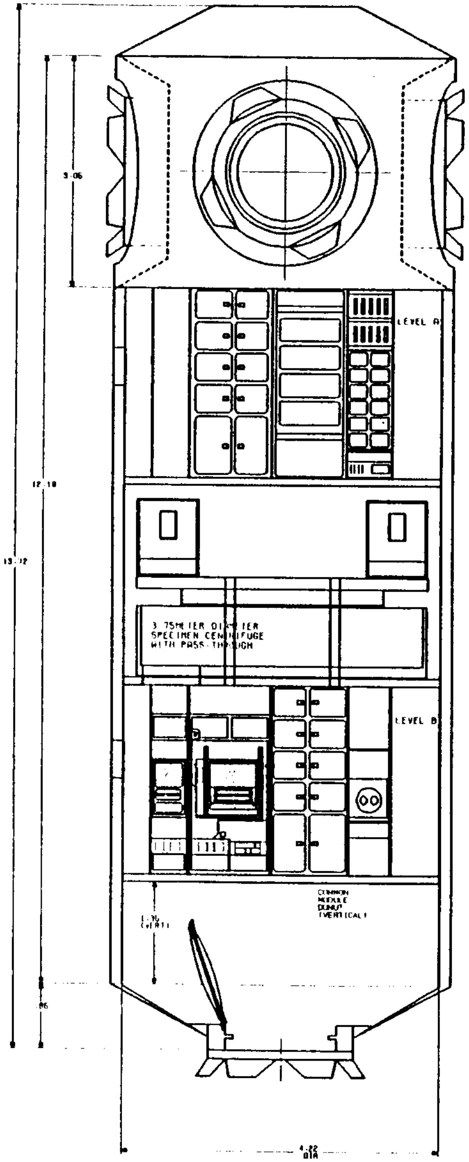
RACK NUMBER	RACK VOLUME (CUBIC M)	EQUIPMENT	
16	2	LARGE PRIMATE HOLDING FACILITY (•58), SPECIMEN FOOD AND WATER (•86A,87A).	
17	1	STORAGE.	
18	1	ADDITIONAL RODENT HOLDING FACILITY (•52B).	
19	0.5	STORAGE.	
20	1	METABOLIC FACILITY (•).	
21	2	21C CENTRIFUGE CONTROLS, STORAGE.	21R
22	1	22C OPTIONAL SECOND 2.75 M DIAMETER ARTIFICIAL GRAVITY CENTRIFUGE(•63A)	22R MINILAB OR EXPERIMENT SPECIFIC EQUIPMENT
23	2	23C	23R
24	1	24C	24R
25	1	STORAGE.	
26	1	2 REFRIGERATOR/FREEZERS (•44A,B), FREEZER (•45B).	
27	2	ADDITIONAL PLANT RESEARCH FACILITY (•81A).	
28	2	STORAGE.	
29	1	STORAGE.	
30	1	STORAGE.	
31	0.5	STORAGE.	
	20	TOTAL VOLUME	

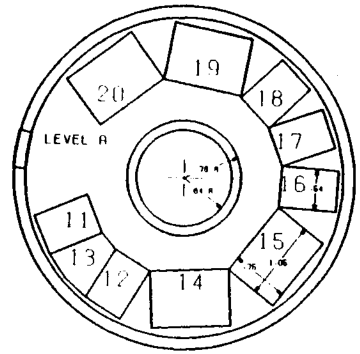
SPACE STATION

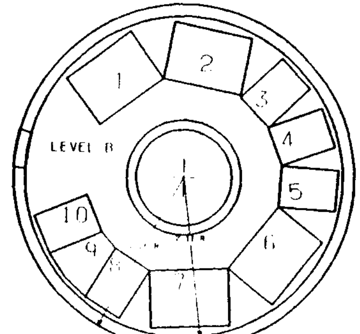
FULL LAB WITH SECOND CENTRIFUGE AND MINILAB OPTIONS

Lockheed

THE VERTICAL LAYOUT WITH THE 3.75M CENTRIFUGE PROVIDES 42.0M^3 FOR EXPERIMENT EQUIPMENT. THE DOUBLE CENTRIFUGE OCCUPIES 14M^3, RACK VOLUME EQUALS 20M^3 AND DRY STOWAGE VOLUME EQUALS 8.0M^3. AT THIS TIME, VERTICAL ARRANGEMENT IS THE PREFERRED INTERNAL LAYOUT BECAUSE WITH SIMILAR EQUIPMENT VOLUMES VERTICAL ARRANGEMENTS ARE SIMPLER AND MORE UNIFORM WITH A GREATER DEGREE OF COMMONALITY POSSIBLE. VERTICAL MODULE PACKAGING ALSO APPEARS TO BE MORE SIMPLY ARRANGED ALLOWING MORE WORKING SPACE AS WELL AS HIGHER PACKAGING EFFICIENCY RESULTING IN MORE DESIRABLE EQUIPMENT ACCOMMODATION THAN HORIZONTAL ARRANGEMENTS.







NON-HUMAN LAB EQUIPMENT

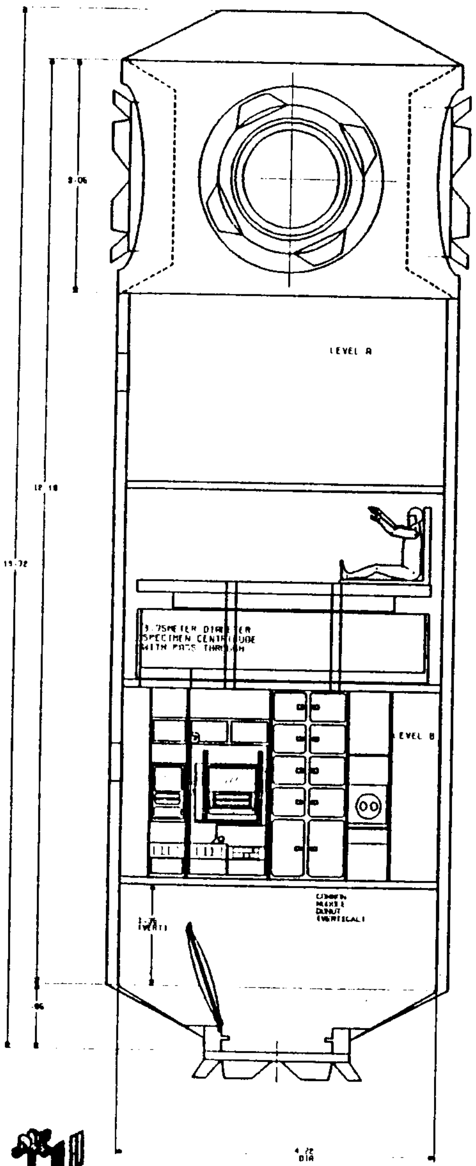
RACK NUMBER	RACK VOLUME (CUBIC M)	EQUIPMENT
1	2	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(•124), SPECTROPHOTOMETER (•206), MASS SPEC/GAS ANALYZER (•163), ANIMAL MONITORING (•203).
2	2	STORAGE.
3	1	HAND WASHER (#100).
4	1	INCUBATOR CO2(•202), EGG INCUBATOR (•76), CELLS (•90), FREEZER(•45A),LABORATORY CENTRIFUGE (•28).
5	1	PLANT RESEARCH FACILITY (•81).
6	2	DATA SYSTEM (•33-36), COMPUTER (•51), STRIP CHART RECORDER (•162), MICROPROCESSOR (•209), VIDEO CAMERA AND RECORDER (•141).
7	2	CAGE WASHER (•88), SPECIMEN FOOD AND WATER (•96,97), STORAGE.
8	1	RODENT STANDARD HOLDING FACILITY (#52A).
9	1	STORAGE, PH/ION ANALYZER (#208), OSCILLOSCOPE (•207), MICROSCOPES (•), PRIMATE KIT (•205).
10	1	RODENT STANDARD HOLDING FACILITY (#52B).
XX	14	3.75 METER DIAMETER SPECIMEN RESEARCH CENTRIFUGE.
11	1	CENTRIFUGE CONTROLS (•63), STORAGE.
12	1	PLANT RESEARCH FACILITY (•81A).
13	1	REFRIGERATOR/FREEZER (•44A), ENVIRONMENTAL MONITOR (•142), PHYSIOLOGICAL AMPLIFIER (•134), DOSIMETER (•125), SMALL MASS MEASUREMENT (•112).
14	2	STORAGE.
15	2	RODENT BREEDING HOLDING FACILITY (•153).
16	1	REFRIGERATOR/FREEZERS(•44B,45B), SPECIMEN FOOD AND WATER(•96A,97A).
17	1	METABOLIC HOLDING FACILITY.
18	1	RODENT STANDARD HOLDING FACILITY (•52C).
19	2	LARGE PRIMATE HOLDING FACILITY (•58), STORAGE.
20	2	STORAGE.
	42	TOTAL VOLUME

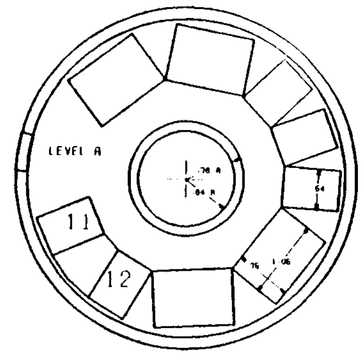
SPACE STATION

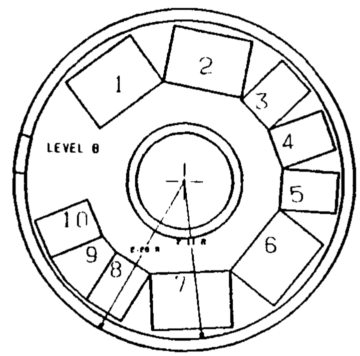
FULL LAB WITH LARGE CENTRIFUGE

Lockheed

THE 1/2 LABORATORY MODULE VERTICAL ARRANGEMENT WITH A LARGE (3.75M) CENTRIFUGE UTILIZES 30.0M^3 OR TWO LEVELS IN WHICH 12.0M^3 IS ANIMAL-PLANT RESEARCH EQUIPMENT AND 18.0M^3 IS SHARED PLANT-ANIMAL AND HUMAN RESEARCH EQUIPMENT.







NON-HUMAN LAB EQUIPMENT

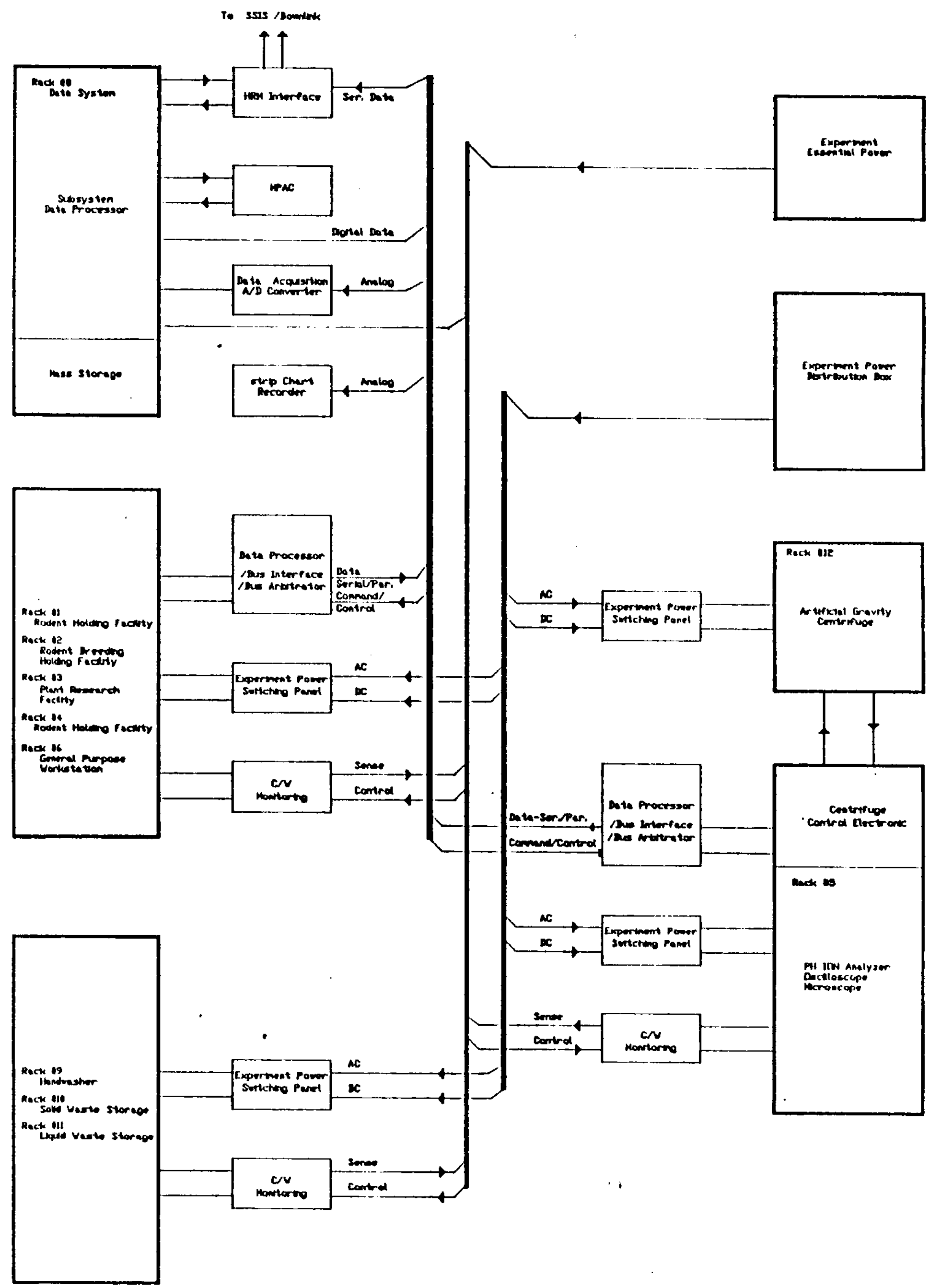
RACK NUMBER	RACK VOLUME (CUBIC M)	USER DESIGNATION	EQUIPMENT
1	2	NON-HUMAN	GENERAL PURPOSE WORK STATION (#11), DISSECTION KIT(•124), SPECTROPHOTOMETER (•206), MASS SPEC/GAS ANALYZER (•183), ANIMAL MONITORING (•203).
2	2	NON-HUMAN	STORAGE.
3	1	NON-HUMAN	HAND WASHER (#100).
4	1	NON-HUMAN	INCUBATOR CO2(•202), EGG INCUBATOR (•78), CELSS (•80), FREEZER(•45A),LABORATORY CENTRIFUGE (•28).
5	1	NON-HUMAN	PLANT RESEARCH FACILITY (•81).
6	2	1 H, 1 N-H	DATA SYSTEM (•33-36), COMPUTER (•61), STRIP CHART RECORDER (•162), MICROPROCESSOR (•209), VIDEO CAMERA AND RECORDER (•141).
7	2	NON-HUMAN	CAGE WASHER (•98), SPECIMEN FOOD AND WATER (•96,97), STORAGE.
8	1	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52A).
9	1	NON-HUMAN	STORAGE, PH/ION ANALYZER (#208), OSCILLOSCOPE (•207), MICROSCOPES (•).
10	1	NON-HUMAN	RODENT STANDARD HOLDING FACILITY (#52).
XX	14	7 H, 7 N-H	3.75 METER DIAMETER SPECIMEN RESEARCH CENTRIFUGE
11	1	.5 H, .5 NH	CENTRIFUGE CONTROLS (•63), STORAGE.
12	1	.5 H, .5N-H	REFRIGERATOR/FREEZERS (•44,45), ENVIRONMENTAL MONITOR (•142), PHYSIOLOGICAL AMPLIFIER (•143), DOSIMETER (•125), SMALL MASS MEASUREMENT (•112).
	21 9	NON-HUMAN HUMAN	TOTAL VOLUME

LARGE CENTRIFUGE OPTION

SPACE STATION

Lockheed

ELECTRICAL POWER AND DATA SERVICES FOR A TYPICAL EQUIPMENT ARRANGEMENT IS SHOWN IN THIS FIGURE. DETAIL DIAGRAMS OF THIS TYPE WERE USED TO ASSIST IN DEFINING COMMON REQUIREMENTS FOR EQUIPMENT GROUPS AND DEVELOPMENT OF CANDIDATE COMMON ELEMENTS FOR THE LSRF.



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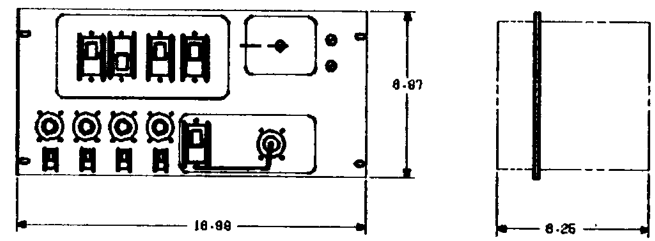
ELECTRICAL INTERFACES - 1/2 LAB

RACK STANDARDIZED INTERFACES ARE DESIGNED WITH THE OBJECTIVE OF SUPPORTING RACK MOUNTED HARDWARE FOR ALL MAJOR SUBSYSTEMS SHOWN ON THE FOLLOWING THREE PAGES.

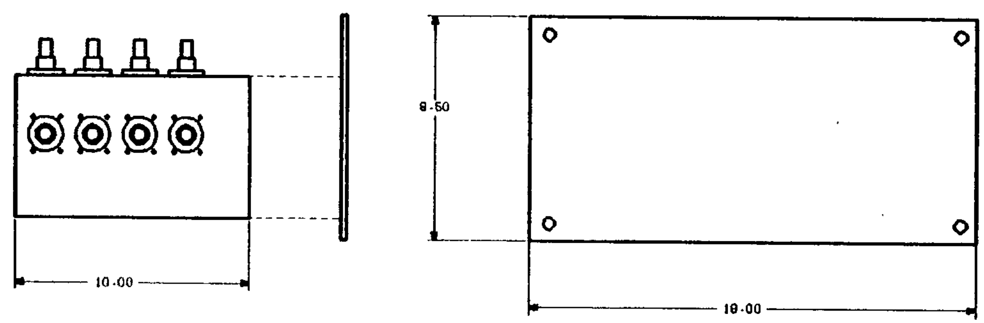
THE RACK STANDARD INTERFACES ARE ADDITIVE TO THE INDIVIDUAL RACKS AS REQUIRED TO SUPPORT THE CONTENTS OR ACTIVITIES AT THAT RACK.

1) POWER EPSP



2) DATA PROCESSOR/BUS INTERFACE/BUS ARBITRATOR

MICROPROCESSOR & INTERFACES



RACK STANDARD INTERFACE CANDIDATES

3) CAUTION AND WARNING

THIS WILL REQUIRE ONLY A CONNECTOR - MAY BE INTEGRATED WITH EPSP

4) THERMAL COOLING - AVIONICS AIR

INLET & OUTLET FOR ABOUT 100 MM DIA AIR DUCTS

5) THERMAL COOLING - EXPERIMENT UNIQUE

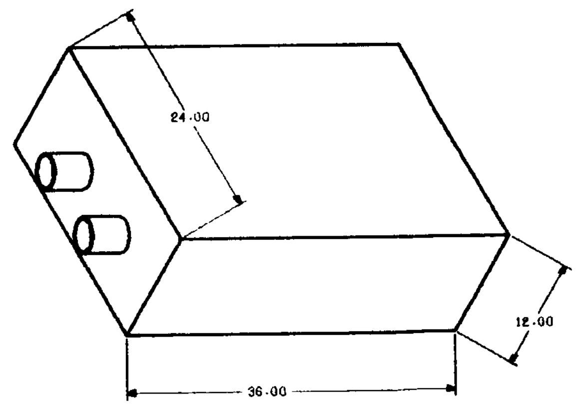
A) WATER LOOP AT ABOUT 24 DEGREES CENTIGRADE

INLET AND OUTLET ABOUT 12 MM DIA WATER LINES

B) HEAT PIPE(S) TO THERMAL BUS AT ABOUT ZERO DEGREES CENTIGRADE

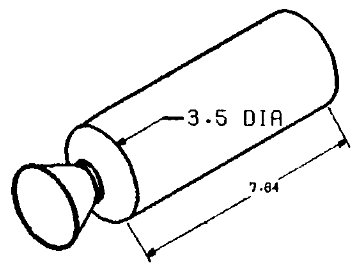
APPROXIMATELY 30 MM DIA HEAT PIPES

6) ANIMAL ECLSS - PROVIDES THERMAL & HUMIDITY CONTROL AS WELL AS AIR REVITALIZATION FOR ANIMAL FACILITIES



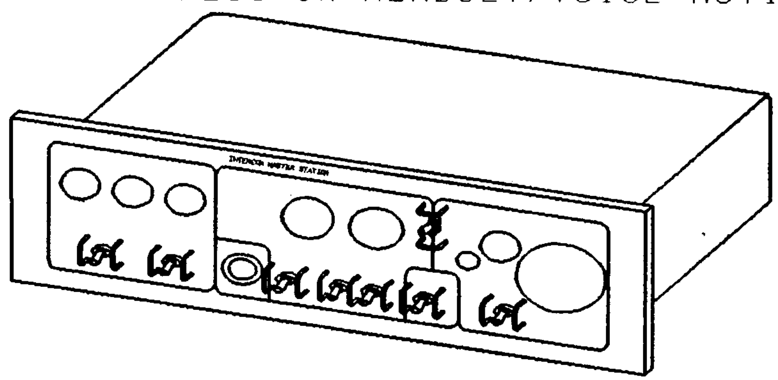
RACK STANDARD INTERFACE CANDIDATES

7) FIRE SUPRESSION - LIKELY A FREON BOTTLE TYPE



8) VIDEO CONNECTOR - CONNECTOR INTERFACE THAT MAY BE INTEGRATED WITH EPSP

9) INTERCOM - PANEL WITH SPEAKER, MICROPHONE, TO/FROM SWITCHES, JACKS TO PLUG IN HEADSET/VOICE ACTIVATED MICROPHONE.

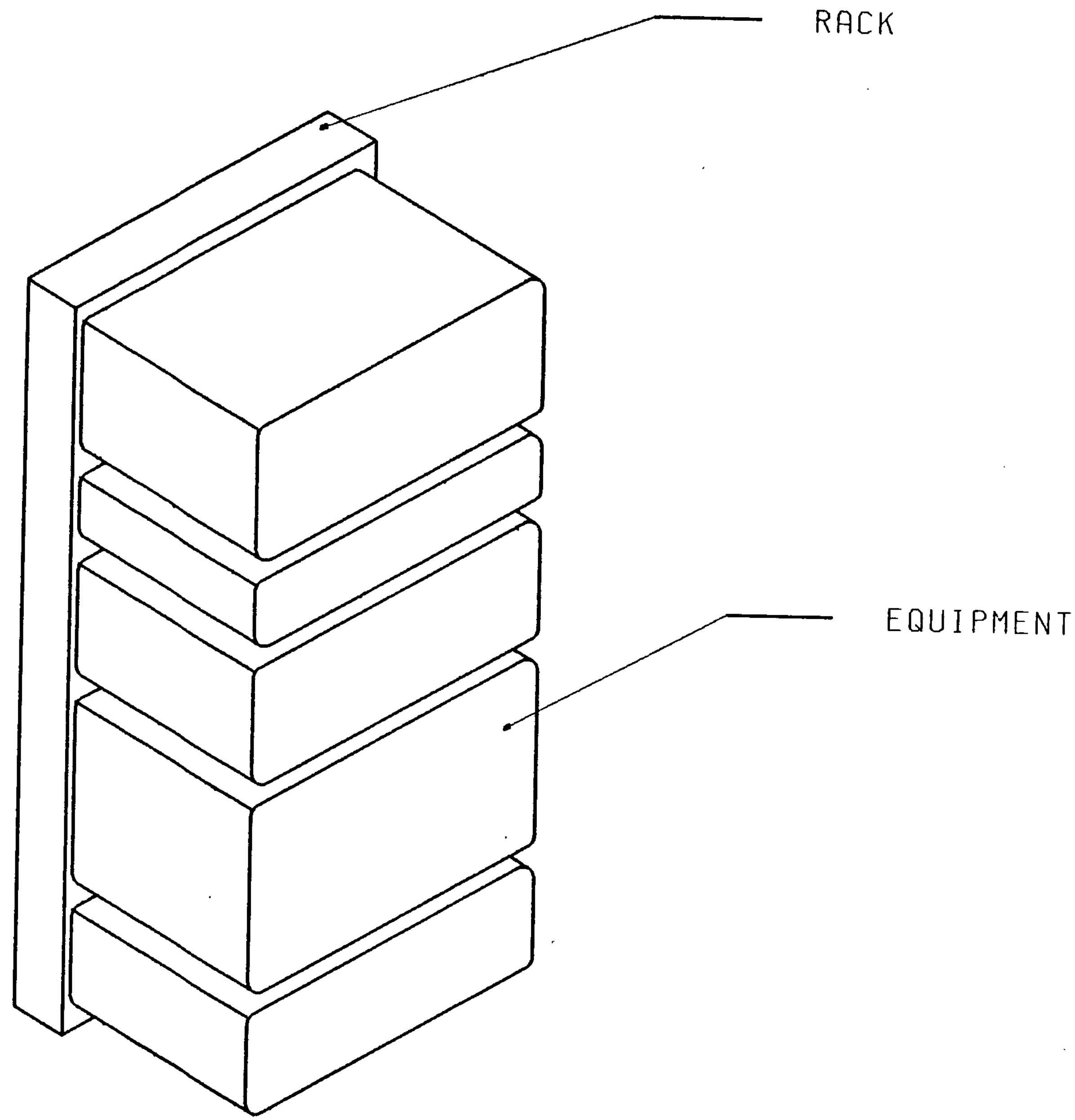


SPACE STATION

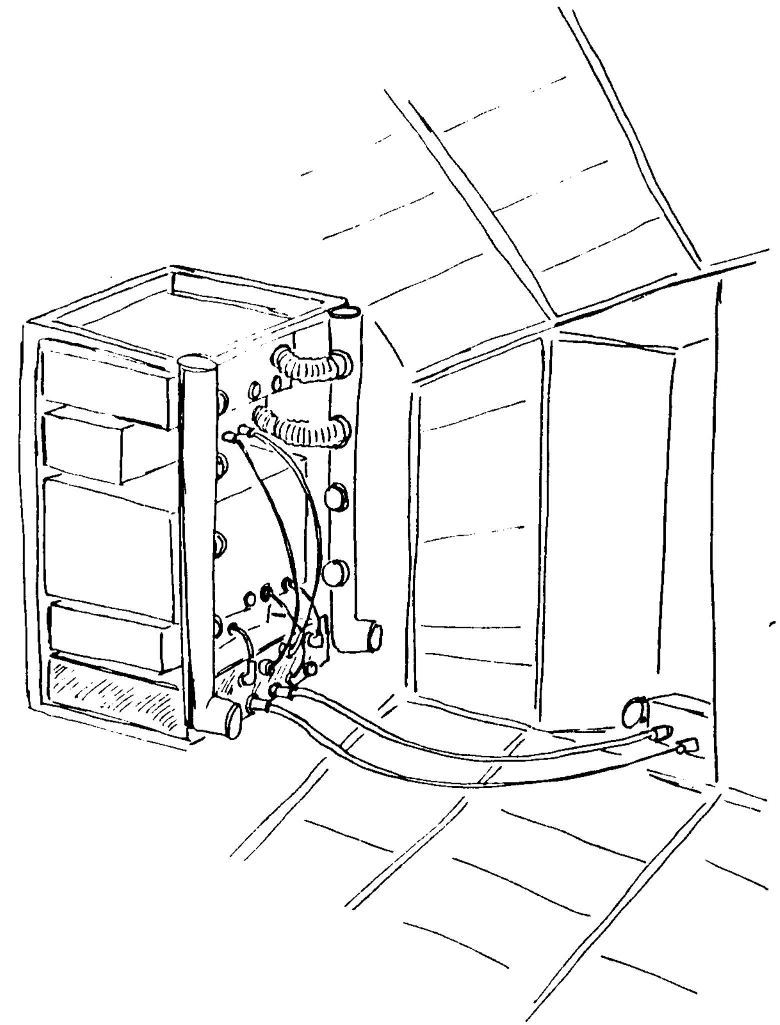
RACK STANDARD INTERFACE CANDIDATES

Lockheed

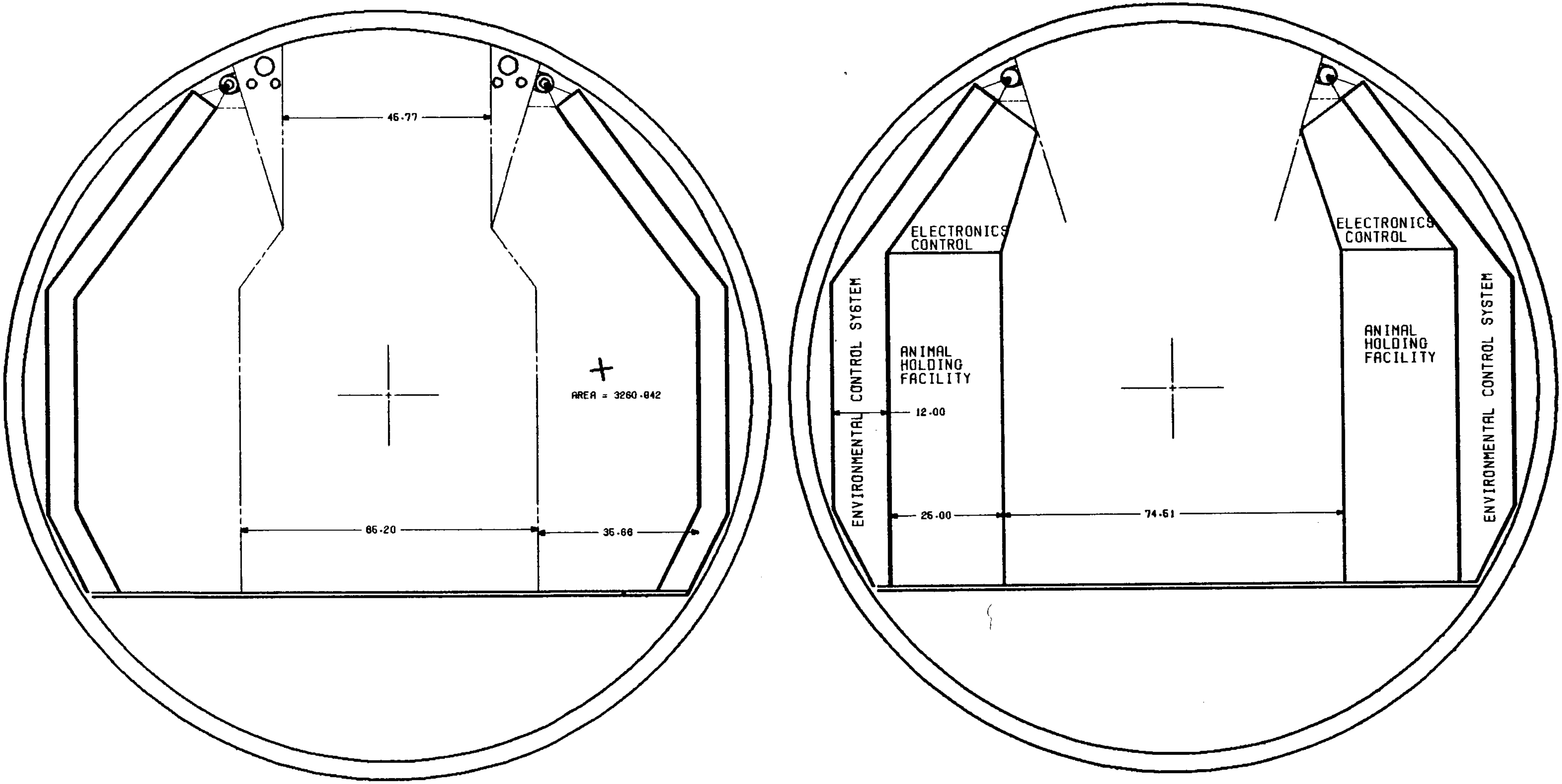
SECONDARY STRUCTURE OF THE LSRF IS DESIGNED TO BE COMPATIBLE WITH COMMON MODULE INTERNAL ARCHITECTURE AND PROVIDE FOR EASY TRANSITION OF HARDWARE FOR ON-ORBIT OR GROUND CHANGEOUT MAINTENANCE AND SERVICING ACTIVITIES.



SECONDARY STRUCTURE OPTIONS - EASY TRANSITION



PLUG-IN RACK MODULE



SPACE STATION

SECONDARY STRUCTURE IN MODULE

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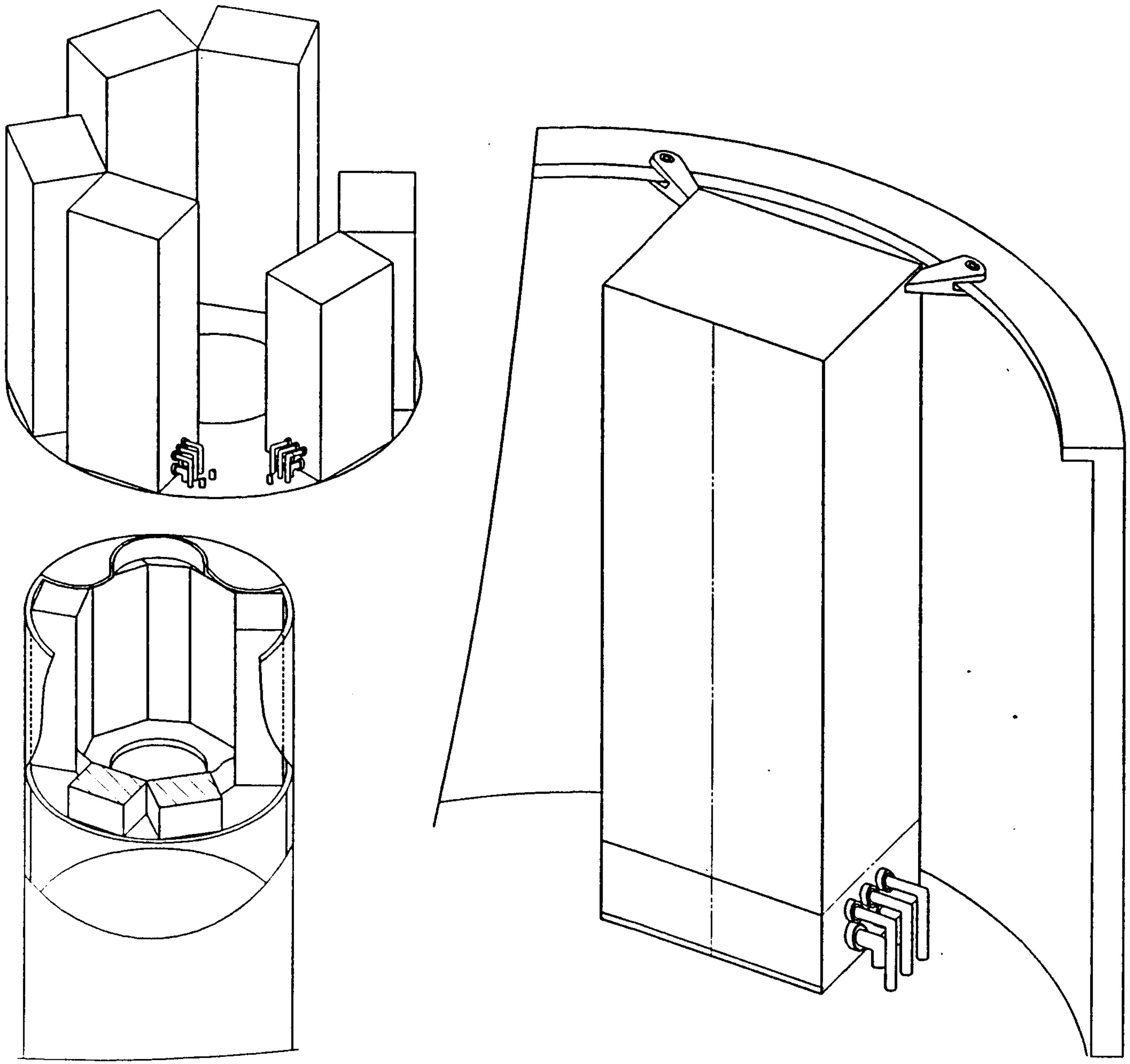
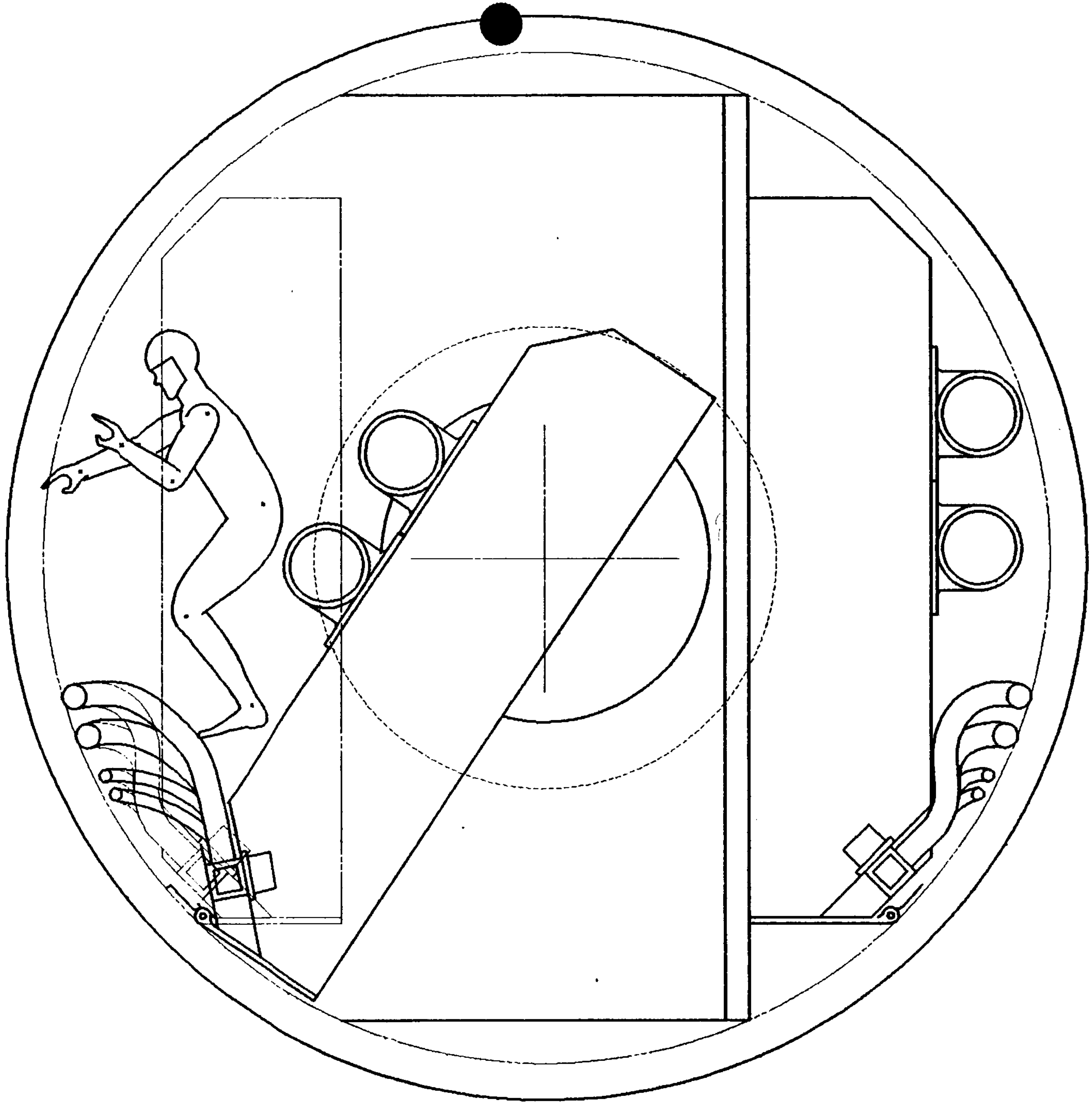


SECONDARY STRUCTURE IN MODULE



RACK REPOSITIONING FOR WALL ACCESS

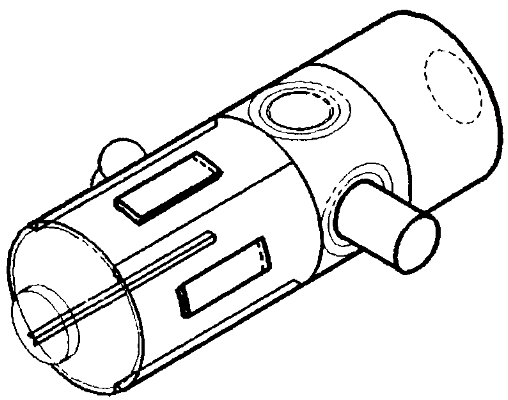
SPACE STATION

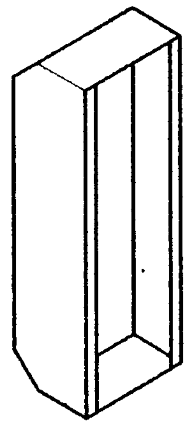
Lockheed

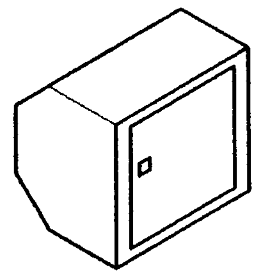
THE LSRF WILL BE AN ELEMENT OF THE SPACE STATION SCIENCE LABORATORY MODULE AND CONSISTS OF A COMMON MODULE SHELL WITH INTERNAL AND EXTERNAL STRUCTURAL ELEMENTS, HARD POINTS AND ATTACHMENT INTERFACES. LSRF USES STANDARD RACKS FOR ATTACHING LAB EQUIPMENT AND STOWAGE. THE COMMON MODULE CONTAINS SECONDARY STRUCTURE AND NETWORK DISTRIBUTION SYSTEM FOR LIFE SUPPORT, DATA MANAGEMENT, ELECTRICAL POWER DISTRIBUTION AND FINAL CONDITIONING, THERMAL MANAGEMENT AND COMMUNICATIONS.

THE LAB MODULE STRUCTURE WILL CONSIST OF THE COMMON MODULE SHELL WITH INTERNAL AND EXTERNAL STRUCTURAL ELEMENTS, HARD POINTS AND ATTACHMENT INTERFACES PLUS STANDARD RACKS AND CONTAINERS FOR ATTACHMENT OF LABORATORY EQUIPMENT AND STORAGE.

C.2







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SPACE STATION

MODULE STRUCTURE

Lockheed

INTERNAL LSRF OUTFITTING MUST BE COMPATIBLE WITH EXTERNAL STRUCTURAL FEATURES TO FACILITATE: EQUIPMENT/SPECIMENS/SUPPLIES TRANSFER FROM STS ORBITER INTO THE SLM, EARTH VIEWING, POWER, ECLSS, THERMAL AND DATA MANAGEMENT INTERFACES WITH THE LOGISTICS MODULE AND SAFETY EGRESS REQUIREMENTS FOR CREW IN EMERGENCY SITUATIONS.

- MODULE ATTACHMENT TO SPACE STATION STRUCTURE
- MODULE INTERFACE TO OTHER MODULES
- ATTACHED PAYLOADS
- ATTACHED SOLAR COLLECTORS & RADIATORS
- OPTICAL FIBER, ELECTRICAL & THERMAL ROUTING

LSRF INTERNAL ARRANGEMENTS MUST BE COMPATIBLE WITH COMMON MODULE INTERIOR CHARACTERISTICS SHOWN ON THE FOLLOWING PAGE TO ENSURE PROPER INTERFACE DURING GROUND AND ON-ORBIT ASSEMBLY ACTIVITIES. EARLY IDENTIFICATION AND INPUT OF LSRF REQUIREMENTS ON COMMON MODULE DESIGN WILL ASSURE SMOOTH ACHIEVEMENT OF THIS INTEGRATION.

- OPTICAL FIBER, ELECTRICAL, ECLSS, & THERMAL ROUTING
- ATTACHMENT POINT FOR STANDARD RACKS AND CONTAINERS
- ATTACHMENT POINT FOR CENTRIFUGE
- INDIVIDUAL RACKS & CONTAINERS
- INDIVIDUAL EQUIPMENT ITEMS

SPACE STATION

INTERNAL STRUCTURAL CONSIDERATIONS

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INTERNAL LSRF ARRANGEMENTS MUST BE SUFFICIENTLY FLEXIBLE TO ACCOMMODATE AN INTERNAL/EXTERNAL AIRLOCK; IN ADDITION, BUILT-IN FLEXIBILITY FOR OPTICAL FIBER, ELECTRICAL AND THERMAL PASS-THRU'S MUST BE INCLUDED TO ALLOW FOR PAYLOAD AND/OR CONFIGURATION CHANGES DURING THE TRANSITION FROM THE SPACE STATION IOC THROUGH GROWTH PHASES.

EXTERNAL/INTERNAL

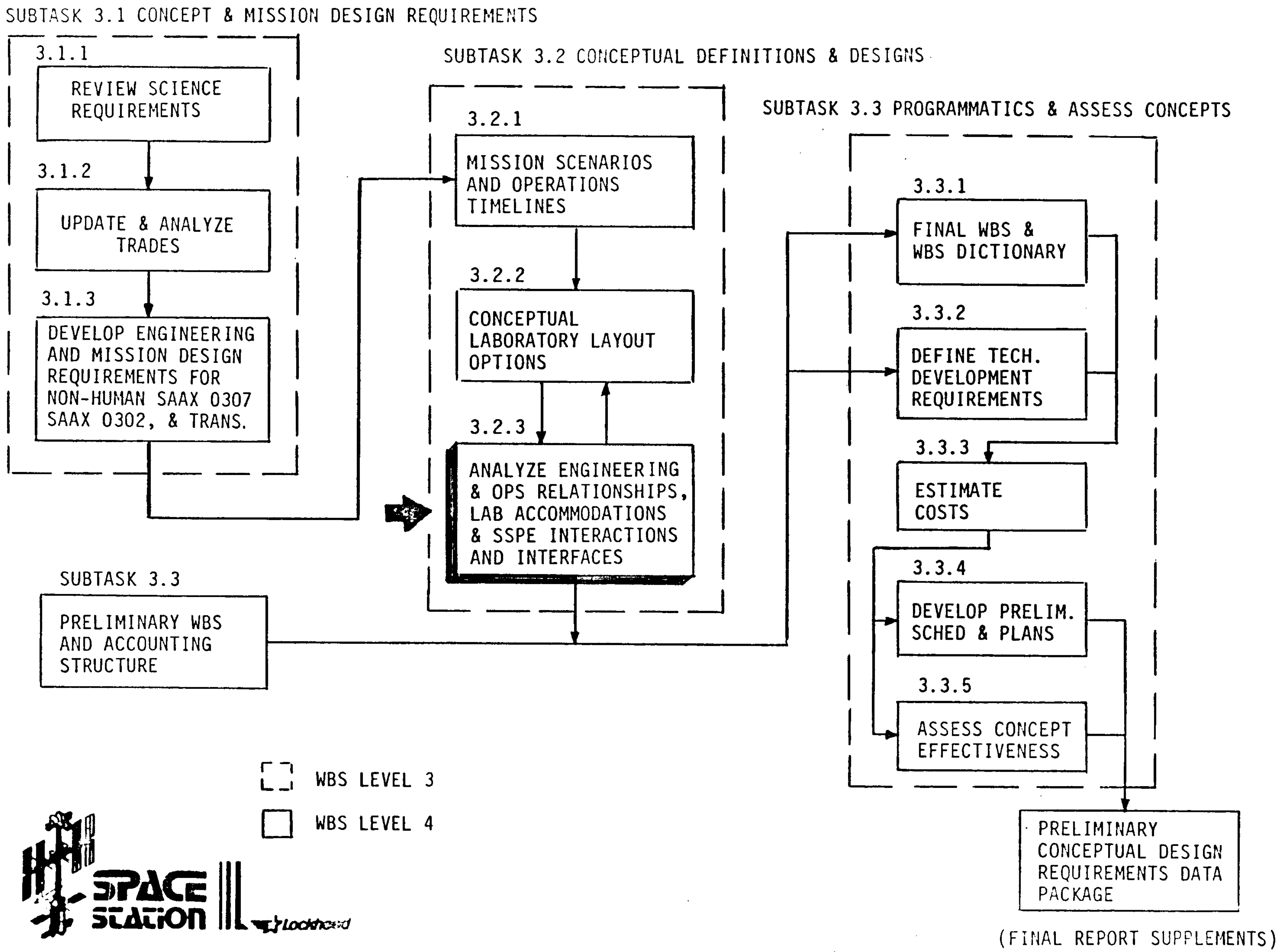
- SCIENTIFIC AIR LOCK FOR LIFE SCIENCE-EXOBIOLOGY
- OPTICAL FIBER, ELECTRICAL & THERMAL PASS-THRU

GROWTH & TRANSITION

- TETHERED PAYLOADS
- EXTERNAL PORCH
- EXTERNAL MANIPULATOR
- ADDITIONAL CENTRIFUGE

THE METHODOLOGY DETAILED ON THE FOLLOWING PAGE PROVIDES THE NECESSARY INFORMATION REQUIRED TO ESTABLISH LSRF COMMONALITY AND FLEXIBILITY TO MEET THE DESIGN REQUIREMENTS FOR THE SLM IOC AND GROWTH VERSIONS.

- DEFINE CONFIGURATION BASED ON REQUIREMENTS
- IDENTIFY LOADS AND ENVIRONMENTS
- PERFORM COMPUTER AIDED ANALYSIS
  - SPACE STATION SYSTEM INTERFACES
  - STRUCTURAL ATTACHMENT OF LAB EQUIPMENT
  - STANDARD RACKS & CONTAINERS
  - UNIQUE LABORATORY EQUIPMENT DESIGNS
- ITERATE CONFIGURATION AND ANALYSIS



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LSRF MISSION SCENARIOS AND INTERNAL LAYOUTS ARE THE PRIMARY DRIVERS INFLUENCING LAB OPERATIONS AND SUPPORT FACILITIES. ELEMENTS IN THE OPERATIONAL SEQUENCE INCLUDE PRE-MISSION, ON-ORBIT, POST-MISSION SUPPORT AND GROUND-BASED FACILITY SUPPORT ACTIVITIES. THESE ACTIVITIES MUST BE FULLY INTEGRATED TO HANDLE ALL EXPERIMENTS IN VARIOUS PHASES OF THE OPERATIONAL SEQUENCE AT ANYTIME.

- MISSION SCENARIO AND LSRF OUTFITTING LAYOUTS DRIVE EXPERIMENT OPERATIONS AND SUPPORT FACILITIES
  - PRE-MISSION SEQUENCE
  - ON-ORBIT AND GROUND MISSION OPERATIONS
  - POST MISSION SUPPORT

- PRE-, DURING-, AND POST-MISSION OPERATIONS AND FACILITIES MUST BE INTEGRATED TO HANDLE ALL THE EXPERIMENTS IN THE PIPELINE AT ANYTIME

THE PRE-MISSION ACTIVITY SEQUENCE ENCOMPASSES SEVEN FUNCTIONS RANGING FROM EXPERIMENT SELECTION, DEFINITION, AND PLANNING TO LOADING SPECIMENS ONTO THE SHUTTLE FOR TRANSFER INTO ORBIT. ON-ORBIT OPERATION INCLUDES INTEGRATING EXPERIMENT UNIQUE EQUIPMENT (EUE), CORE, AND LSLE EQUIPMENT INTO THE LAB, TRANSFERRING SPECIMENS INTO THE LAB FROM SHUTTLE, RESUPPLYING LAB CONSUMABLES, PERFORMING EXPERIMENTS AND RETURNING EXPERIMENTAL PRODUCTS TO THE GROUND. POST MISSION SUPPORT FUNCTIONS ARE PRIMARILY CONCERNED WITH PROCESSING EXPERIMENTAL DATA AND SPECIMENS AND REFURBISHING EUE, CORE, OR LSLE EQUIPMENT. GROUND BASED FACILITY SUPPORT PROVIDES ON-ORBIT LOGISTICS SUPPORT, COMMAND, REAL AND NON-REAL TIME DATA ACQUISITION FUNCTIONS AND FACILITIES FOR CONDUCTING SYNCHRONOUS EXPERIMENTAL 1G CONTROLS.

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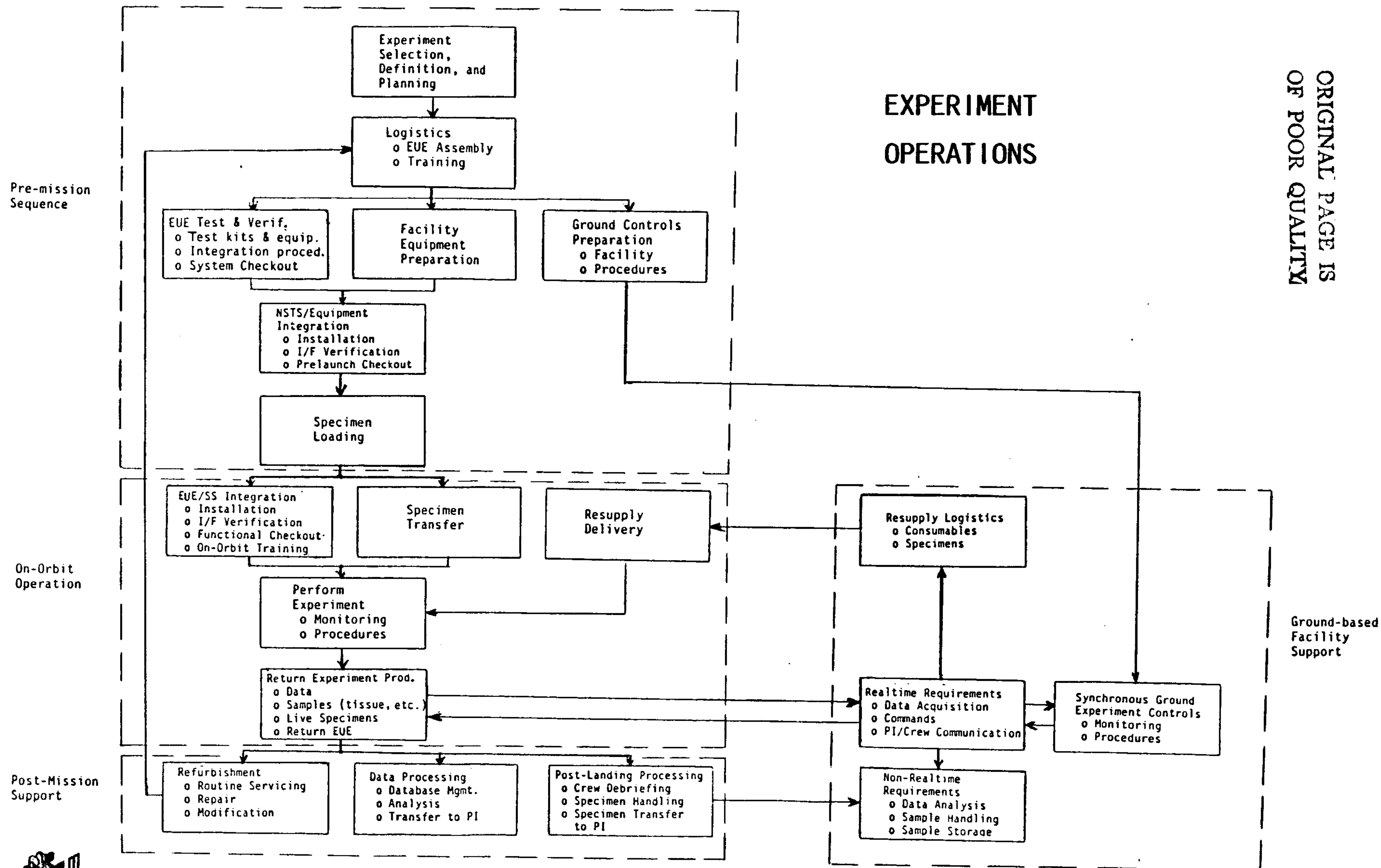
EXPERIMENT OPERATIONS



SPACE STATION

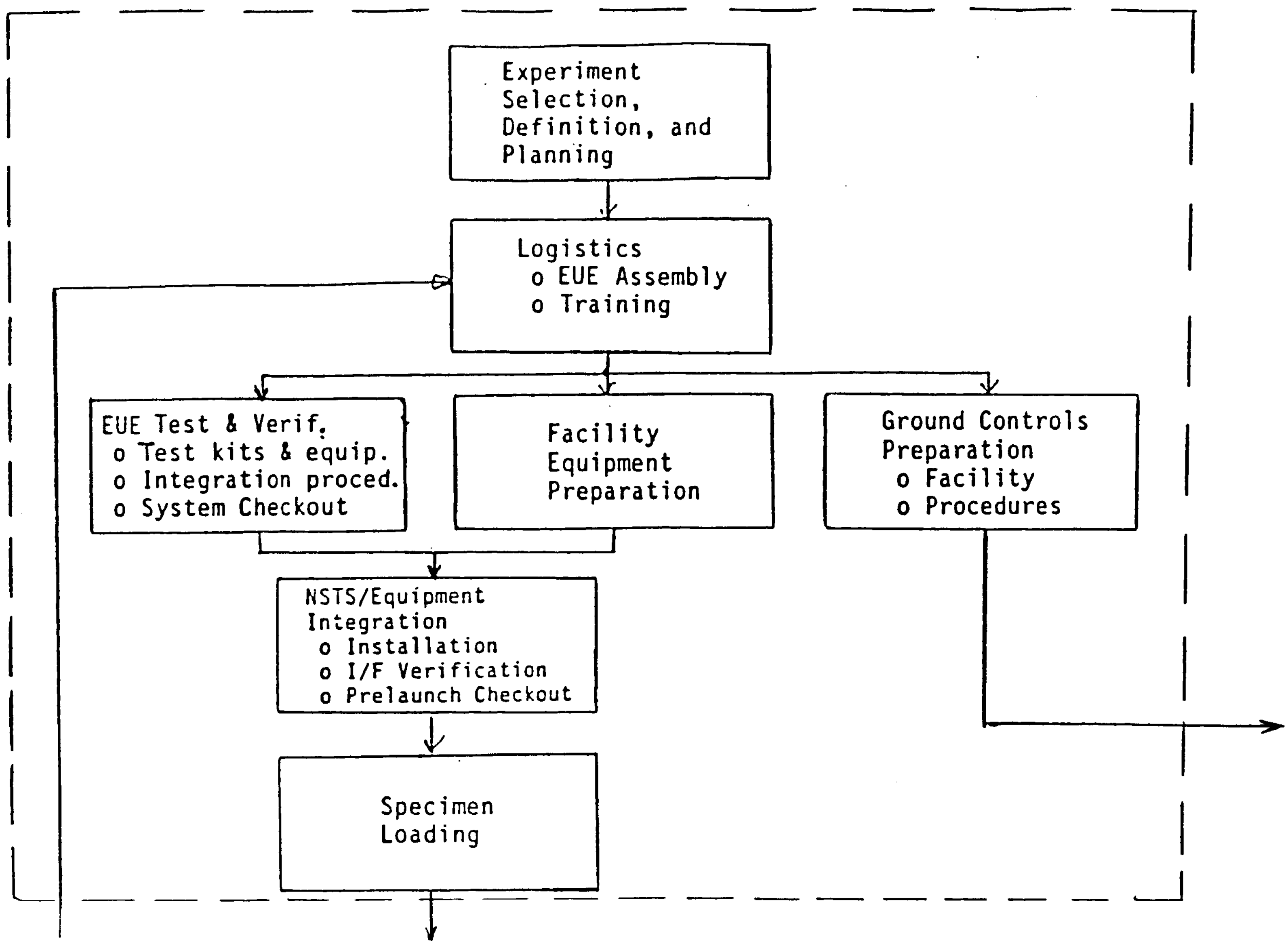
3.2.3 ENGINEERING & OPERATIONAL RELATIONSHIPS, INTERACTIONS, & INTERFACES

Lockheed

SEVEN FUNCTIONAL ELEMENTS COMPRISE THE PRE-MISSION SEQUENCE. EXPERIMENT SELECTION BY NASA AND THE SCIENTIFIC COMMUNITY DRIVES DEFINITION OF MISSION SCENARIOS, EQUIPMENT AND OPERATIONAL TIMELINES. LOGISTICS FUNCTIONS SUPPORTING PRE-MISSION ACTIVITIES ARE CONCERNED PRINCIPALLY WITH ASSEMBLING EUE, CORE, AND LSLE (LSRF) EQUIPMENT FOR INTEGRATION INTO THE LSRF PORTION OF THE SLM AND THE APPROPRIATE TRAINING REQUIRED FOR USING THE EQUIPMENT; TEST AND VERIFICATION AND SYSTEM CHECKOUT OF LSRF EQUIPMENT WITH THE GROUND CONTROL FACILITY PRIOR TO INTEGRATION INTO STS ORBITER; TEST AND VERIFICATION OF LSRF EQUIPMENT - STS INTERFACES PRIOR TO LAUNCH, AND LOADING SPECIMENS INTO THE ORBITER AS LATE IN THE NSTS PROCESSING FLOW AS FEASIBLE.

EXPERIMENT OPERATIONS (CONT'D)

Pre-mission
Sequence



SPACE STATION

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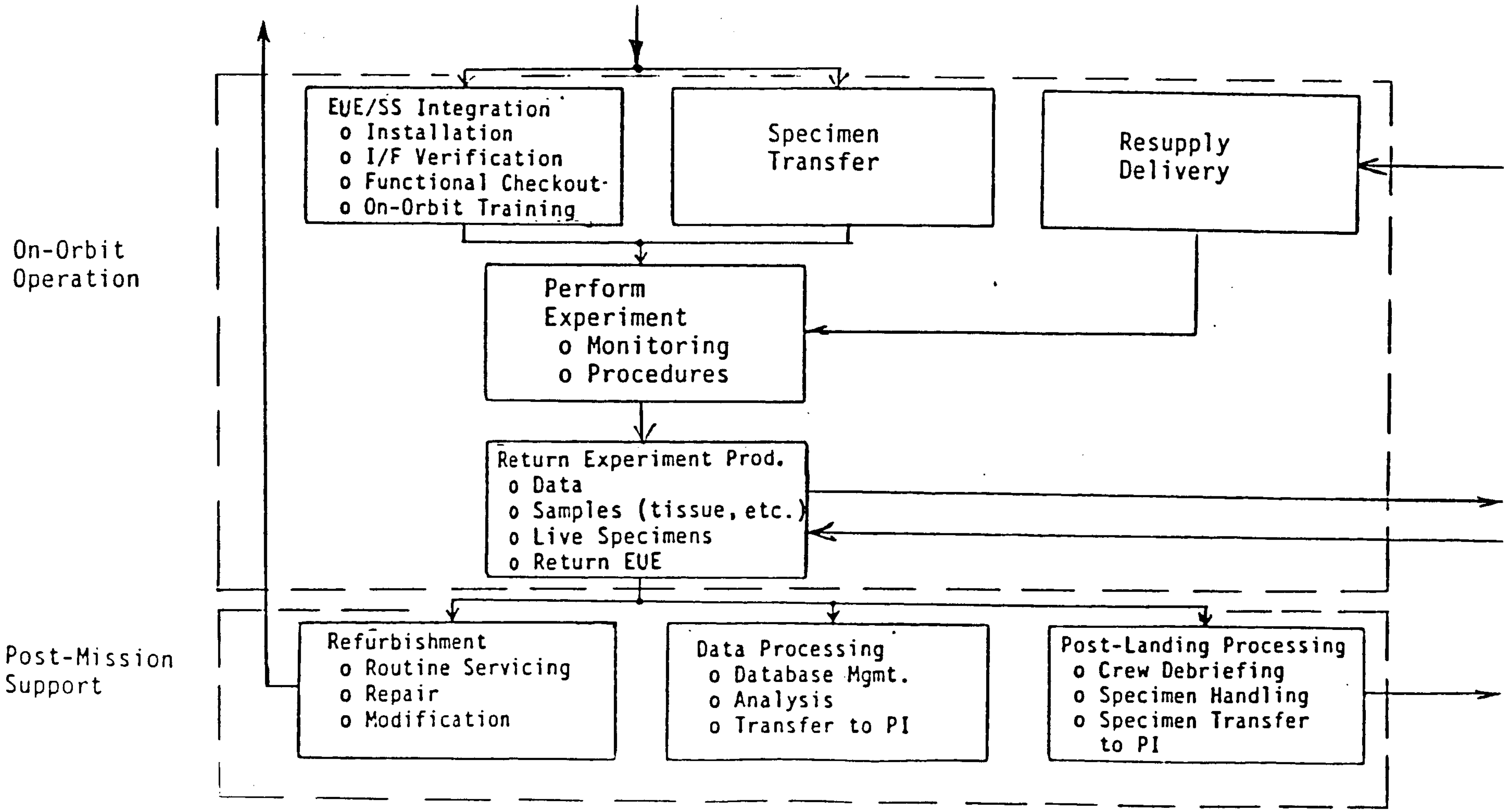
THE ON-ORBIT OPERATION FUNCTIONS ENCOMPASS ON-ORBIT INTEGRATION, I/F VERIFICATION, AND FUNCTIONAL CHECKOUT OF LSRF EQUIPMENT WITH OTHER SS ELEMENTS (E.G. LOGISTICS MODULE). SPECIMENS TRANSPORTED VIA THE NSTS ORBITER WILL BE TRANSFERRED TO THE SLM MAINTAINING BIOISOLATION TO THE MAXIMUM EXTENT PRACTICABLE; EXPERIMENT RELATED-ECLSS CONSUMABLES NECESSARY TO CONDUCT THE EXPERIMENTS WILL BE TRANSFERRED FROM THE LOGISTICS MODULE TO THE SLM WHERE EXPERIMENTS WILL BE PERFORMED AND THE EXPERIMENTAL PRODUCTS (E.G. DATA, TISSUE SAMPLES) AND LSRF EQUIPMENT REQUIRING CHANGEOUT (E.G., ORU) WILL BE RETURNED TO THE GROUND VIA DOWNLINKING TO THE GROUND FACILITY OR VIA NSTS ORBITER TRANSFER.

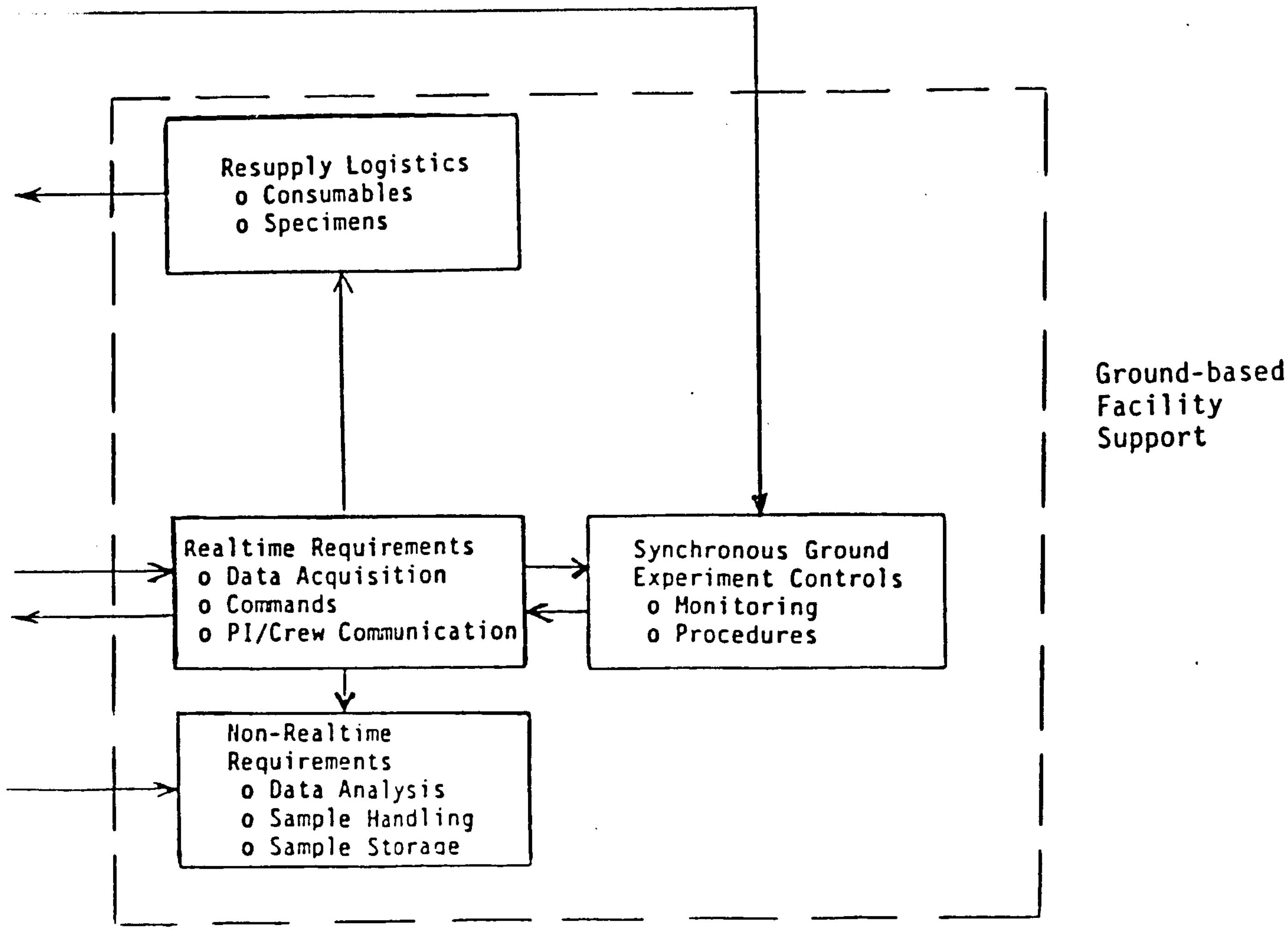
POST-MISSION SUPPORT INCLUDES REPAIR-REFURBISHMENT OF ORU'S AND ROUTINE GROUND MAINTENANCE OF EQUIPMENT THAT COULD NOT BE MAINTAINED ON-ORBIT. POST-LANDING DATABASE MANAGEMENT, DATA ANALYSIS AND SPECIMEN HANDLING WILL BE PERFORMED IN GROUND BASED FACILITIES AT KSC AND THE CONTRACTOR'S SITE.

EXPERIMENT OPERATIONS (CONT'D)

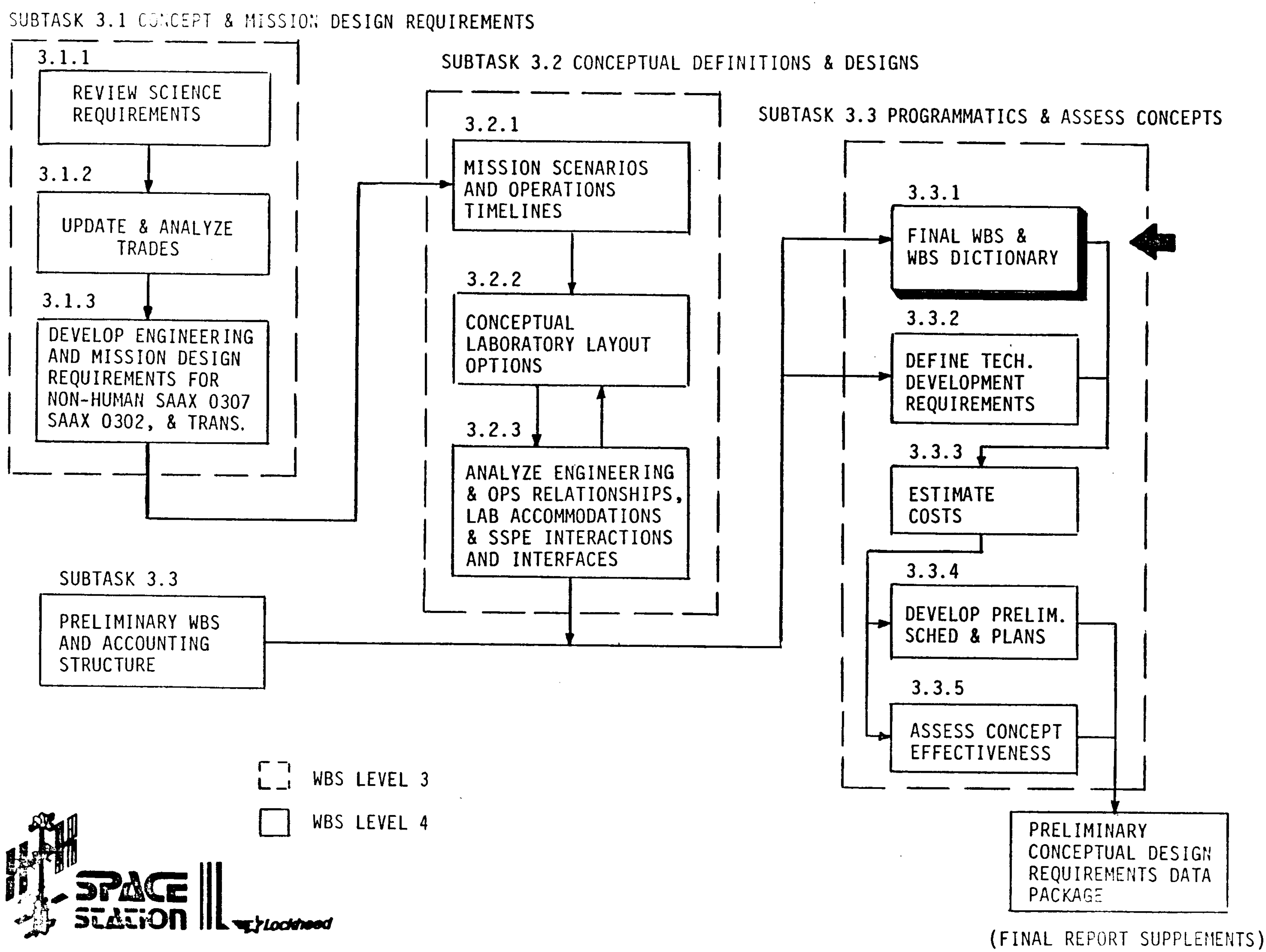


GROUND BASED FACILITIES SUPPORTING PRE-MISSION, ON-ORBIT, AND POST-MISSION ACTIVITIES INCLUDE: (1) THE PAYLOAD OPERATIONS CONTROL CENTER (POCC) RESPONSIBLE FOR MANAGING AND PERFORMING NORMAL P/L OPERATIONS AND COMMANDING, COORDINATING RELATED EXPERIMENTS, AND SERVING AS THE CENTER FOR P/L PERFORMANCE ANALYSIS. (2) THE SPACE STATION SUPPORT CENTER (SSSC) WHICH HAS RESPONSIBILITY FOR STRATEGIC ASPECTS OF SPACE STATION OPERATION (E.G. LAUNCH, RENDEZVOUS, ASSEMBLY AND CONSTRUCTION, ORBITAL ADJUSTMENT) AND POCC COORDINATION AND MONITORING; (3) AN INTEGRATED LOGISTICS SUPPORT FACILITY(ILS) CAPABLE OF RESUPPLYING CONSUMABLES TO THE LSRF AND ACQUIRING EQUIPMENT RETURNED FOR REPAIR OR MAINTENANCE, ACQUIRING, PROVISIONING AND MAINTAINING SPARES, AND TRAINING PERSONNEL IN MAINTENANCE OF SPACE STATION HARDWARE ON-ORBIT OR ON THE GROUND; (4) A GROUND FACILITY IN WHICH 1G EXPERIMENTS MIMICKING ON-ORBIT EXPERIMENTS CAN BE CONDUCTED CONCURRENTLY WITH ORBITAL EXPERIMENTS.

EXPERIMENT OPERATIONS (CONT'D)



3.2.3 ENGINEERING & OPERATIONAL RELATIONSHIPS, INTERACTIONS, & INTERFACES



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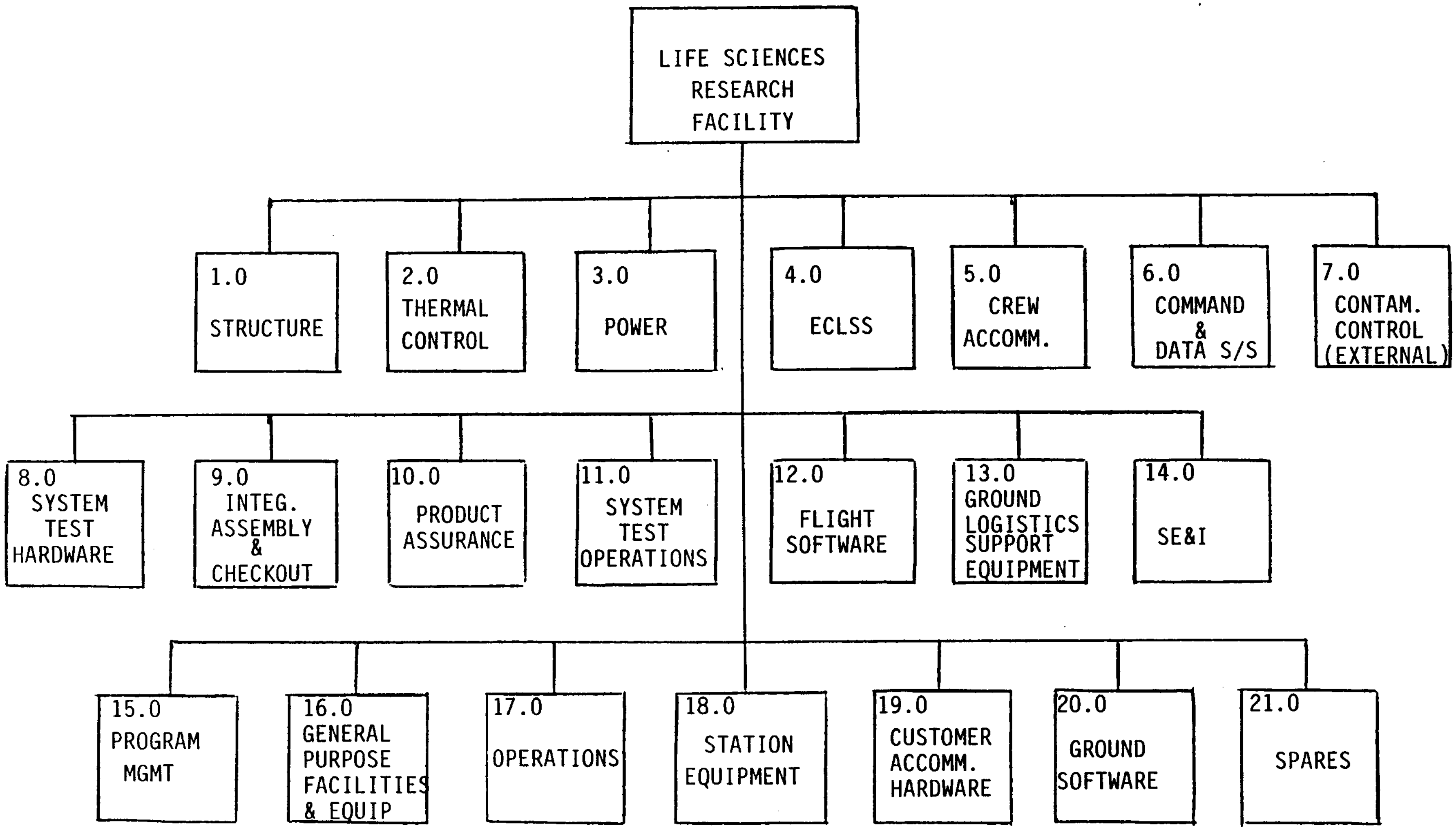
THE WBS REPRESENTS AN UPDATED VERSION OF THE WBS PRESENTED IN THE DECEMBER 1984 REPORT AND CORRESPONDS TO WBS ELEMENTS PRESENTED IN THE SPACE STATION RFP. WBS ELEMENTS 1.0 - 7.0 ADDRESS COMMON MODULE END-ITEMS THAT MUST BE ENHANCED TO ACHIEVE AN OPERATIONAL LSRF BY IOC. DEFINITIONS FOR EACH WBS ELEMENT ARE PROVIDED ON THE FOLLOWING FIVE CHARTS.

WORK BREAKDOWN STRUCTURE



SPACE STATION

3.3.1 WORK BREAKDOWN STRUCTURE AND DICTIONARY

Lockheed

WBS ELEMENT DESCRIPTION

1. Structure

Consists of all structure that bridges between Common Module hardpoints and the structural interfaces of equipment in all other groupings. Includes primary and secondary structure, mechanisms, tanks (pressurized and unpressurized) and subsystem engineering.

2. Thermal Control

Consists of all thermal and thermoelectric equipment. Includes radiators, insulation, liquid cooling systems, gas cooling systems, sensors and controls, heat pipes, thermionics, cold plates and subsystem engineering.

3. Power

Consists of all electrical power equipment including power storage, distribution, conditioning, regulation and control and subsystem engineering.

4. Environmental Control & Life Support

Consists of any required modifications to the Common Module ECLSS and any additional ECLSS items required to support the life science hardware. Includes internal contamination control, temperature and humidity control, pressure and atmospheric composition monitoring and control, ventilation and cabin air distribution, food and potable water supply, waste management systems, trash collection and disposal, equipment and module cleaning and subsystem engineering.

WBS ELEMENT DESCRIPTION (CONT'D)

5. Crew Accommodations

Consists of personnel restraints, tool kits, special purpose lighting, personal hygiene subsystem, emergency medical kits and human factors engineering.

6. Command & Data Handling Subsystem

Consists of data processing, display, entry, memory, peripheral equipment, data bus, and interfaces with the instrumentation and SSIS. Includes displays and controls, instrumentation, communications interfaces, command and data handling, data storage and subsystem engineering.

7. Contamination Control

Consists of external contamination control including effluent control, window cleaning apparatus and shields and covers.

8. System Test Hardware

Consists of equipment items used for qualification, acceptance and other testing activities. Includes equipment used for mechanical, r-f, electrical, thermal and vacuum/thermal test, alignment and mass properties measurement equipment, and equipment interface simulation equipment.

WBS ELEMENT DESCRIPTION (CONT'D)

9. Integration, Assembly & Checkout

Consists of integration and assembly hardware, checkout consoles and supporting hardware, design maintenance and liaison, and tool planning, design and fabrication.

10. Product Assurance

Consists of all efforts to support safety, reliability, quality assurance and maintainability activities.

11. System Test Operations

Consists of the conduct of all systems testing of laboratory equipment. Includes electrical, vibration and acceleration, thermal, EMI, EMC, alignment, calibration, thermal vacuum and acoustic tests and simulation modeling.

12. Flight Software

Consists of the generation and testing of all software for inflight application. Includes software for data handling and processing, command, communication, applications interface, fault isolation, and BITE.

13. Ground Logistics Support Equipment

Consists of equipment required to checkout, handle and transport all material and specimens during inflight, postflight and inflight operations.

WBS ELEMENT DESCRIPTION (CONT'D)

14. Systems Engineering & Integration
Consists of effort required to conduct all SE&I activities. Includes hardware development planning, configuration control, mission analysis, interface requirements, specifications, engineering data, and engineering analyses.

15. Program Management
Consists of effort required to conduct all program management activities. Includes project management and coordination, planning and scheduling, controls, subcontractor/vendor liaison, management data, reviews, and design to cost.

16. General Purpose Facilities and Equipment
Consists of equipment required to conduct and support life science experiments. Includes module specific and other science equipment.

17. Operations
Consists of all operations and procedures associated with the general functions of the science laboratory except for specific experimental protocols. Includes training, logistics, airborne support equipment, maintenance and servicing, mockups, ground operations (preflight, inflight and postflight), flight operations and recovery.

WBS ELEMENT DESCRIPTION (CONT'D)

18. Station Equipment

Consists of secondary equipment required to be housed within the laboratory . Includes safe haven, secondary controls, lighting, caution and warning, fire detection and suppression equipment and work stations.

19. Customer Accommodation Hardware

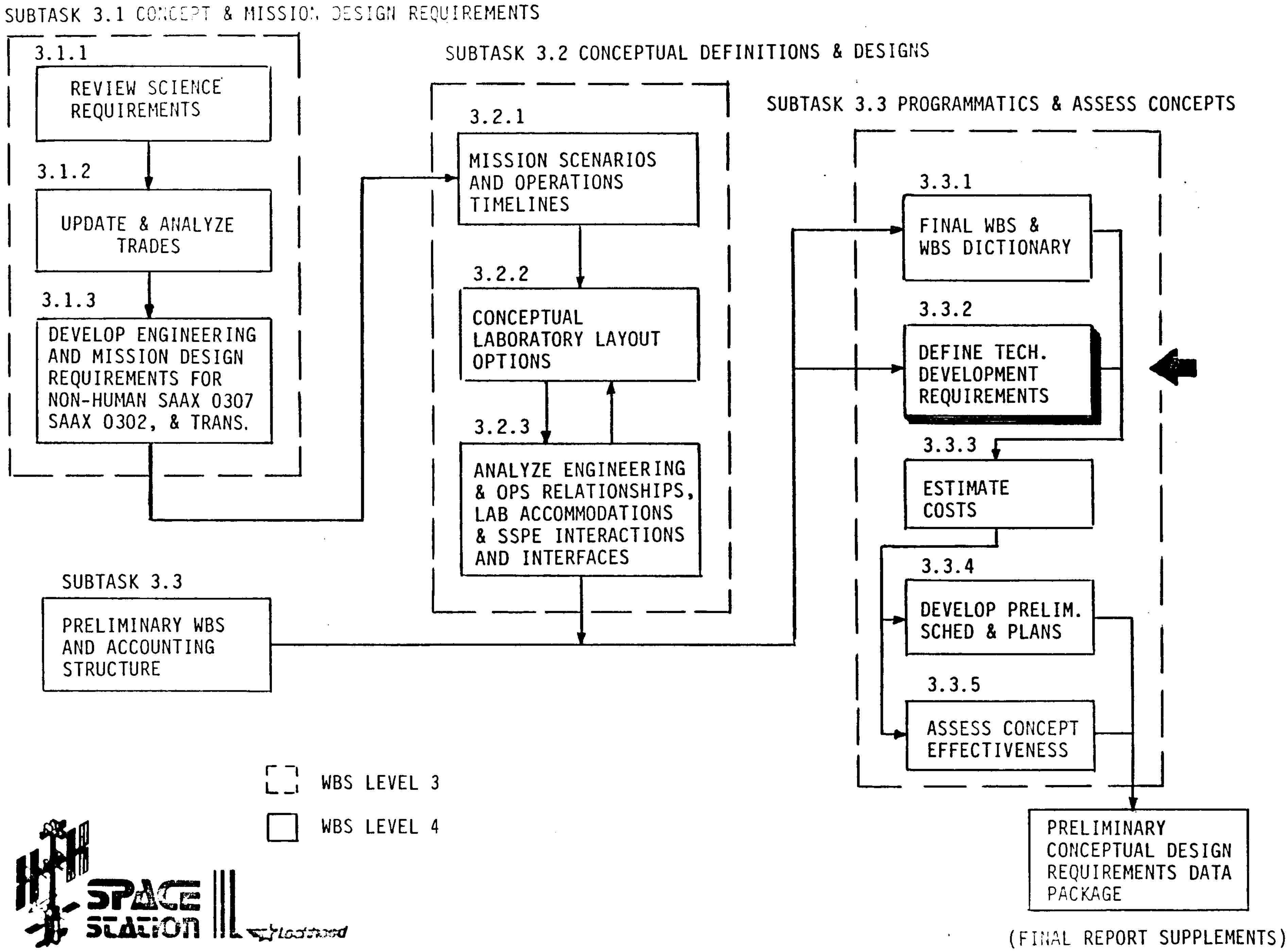
Consists of equipment to support generalized science experiment requirements in the laboratory. Includes electrical, data and thermal interfaces for experiment equipment. Does not include experiment unique equipment.

20. Ground Software

Consists of the generation and testing of all software required for ground operations. Includes software for system test, inflight verification and checkout, data handling and processing, telemetry and command, communications, applications interfaces, and real-time on-orbit interface.

21. Spares

Consists of initial and production spares for hardware items. Includes batteries, filters and light bulbs.



SPACE STATION

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TECHNOLOGY DEVELOPMENT ACTIVITIES WILL PLAY AN INTEGRAL PART IN THE DEVELOPMENT OF A FULLY OPERATIONAL LSRF THAT IS COMPATIBLE WITH OTHER SPACE STATION ELEMENTS. INNOVATION IN ALL THE TECHNOLOGY DEVELOPMENT AREAS LISTED IN THE NEXT FOUR PAGES WILL BE REQUIRED FOR THE IOC AND GROWTH VERSIONS OF THE LSRF.

- LABORATORY EQUIPMENT DESIGN
  - ADVANCED TECHNOLOGY
  - NEW INNOVATION IN APPLICATION OF EXISTING TECHNOLOGY
- CONTAMINATION/BIOISOLATION
  - CONTAMINANT IDENTIFICATION & CONTROL
  - BIOISOLATION OF ANIMALS & ANIMAL SPECIES
- DATA INSTRUMENTATION, MANAGEMENT & PROCESSING
  - BIOSENSOR DEVELOPMENT
  - METHOD, CAPACITY, MEDIA, & SPEED; TEMPORARY/PERMANENT
  - STANDARD INTERFACE MODULES FOR EQUIPMENT
- MATERIALS & PROCESSES
  - WEIGHT REDUCTION
  - CONTAMINATION/TOXICITY/FLAMMABILITY
  - SERVICE LIFE/MAINTAINABILITY/RELIABITY
- ROBOTICS, AUTOMATION, & "SMART" SYSTEMS
  - HUMAN PRODUCTIVITY

- CAGE WASHER
  - DYNAMIC ISOLATION
  - LIQUID CONTROL & PROCESSING
  - BIOISOLATION
  - STERILIZATION
- CELSS EXPERIMENT
  - PLANT & ANIMAL SYSTEMS INTIGRATION
  - BIOISOLATION & CONTAMINATION CONTROL
  - AUTOMATION
- ANIMAL HOLDING FACILITIES
  - WASTE MANAGEMENT
  - LONG TERM FEEDERS
  - ECLSS/BIOISOLATION
  - AUTOMATION

SPACE STATION

LAB EQUIPMENT TECHNOLOGY APPLICATIONS (CONT'D)

Lockheed

- PLANT FACILITIES
  - LIGHTING (POWER EFFICIENT)
  - MICROGRAVITY
  - NUTRIENT SUPPLY SYSTEM(S)
  - MODULARITY/CENTRIFUGE COMPATIBILITY
- RODENT BREEDING FACILITY
  - WASTE MANAGMENT
  - LONG TERM FEEDERS
  - ECLSS/BIOISOLATION
  - MATING ACCOMMODATION
  - NESTING ACCOMMODATION
- METABOLIC FACILITY
  - URINE & FEECES COLLECTION/SAMPLING
  - BIOISOLATION

SPACE STATION

LAB EQUIPMENT TECHNOLOGY APPLICATIONS (CONT'D)

Lockheed

THE VARIABLE GRAVITY CENTRIFUGE IS A PRIME DRIVER IN THE LSRF DESIGN. THE BEARING ASSEMBLY IS A KEY PORTION OF THE CENTRIFUGE. TO MINIMIZE FRICTION AND VIBRATION, MAGNETIC BEARINGS WILL BE DESIGNED FOR THE CENTRIFUGE WITHIN SLM WEIGHT, POWER, AND VOLUME LIMITATIONS.

- CENTRIFUGE
  - MULTIPLE ROTORS
  - BALANCING/MICROGRAVITY
  - BEARINGS
  - ROTARY FLUID JOINTS
  - DRIVE MOTOR
  - CONTROL SYSTEM
  - SLIP RINGS
  - MODULARITY
  - BIOISOLATION
  - CAGE RETRIVAL/AUTOMATION

MAGNETIC
BEARINGS
INC.

Bearing Weights

1 Radial Rotor: 175 lbs
1 Radial Stator: 350 lbs

1 Thrust Stator: 10 lbs

Bearing Volume

1 Radial Rotor and Stator: 2368.8 in^3

1 Thrust Stator: 35 in^3

Power Required

Maximum Voltage: 28 volts

Maximum Current: 40 amps

Load Capacity

Radial Bearing: 2500 lbs

Thrust Bearing: 2500 lbs

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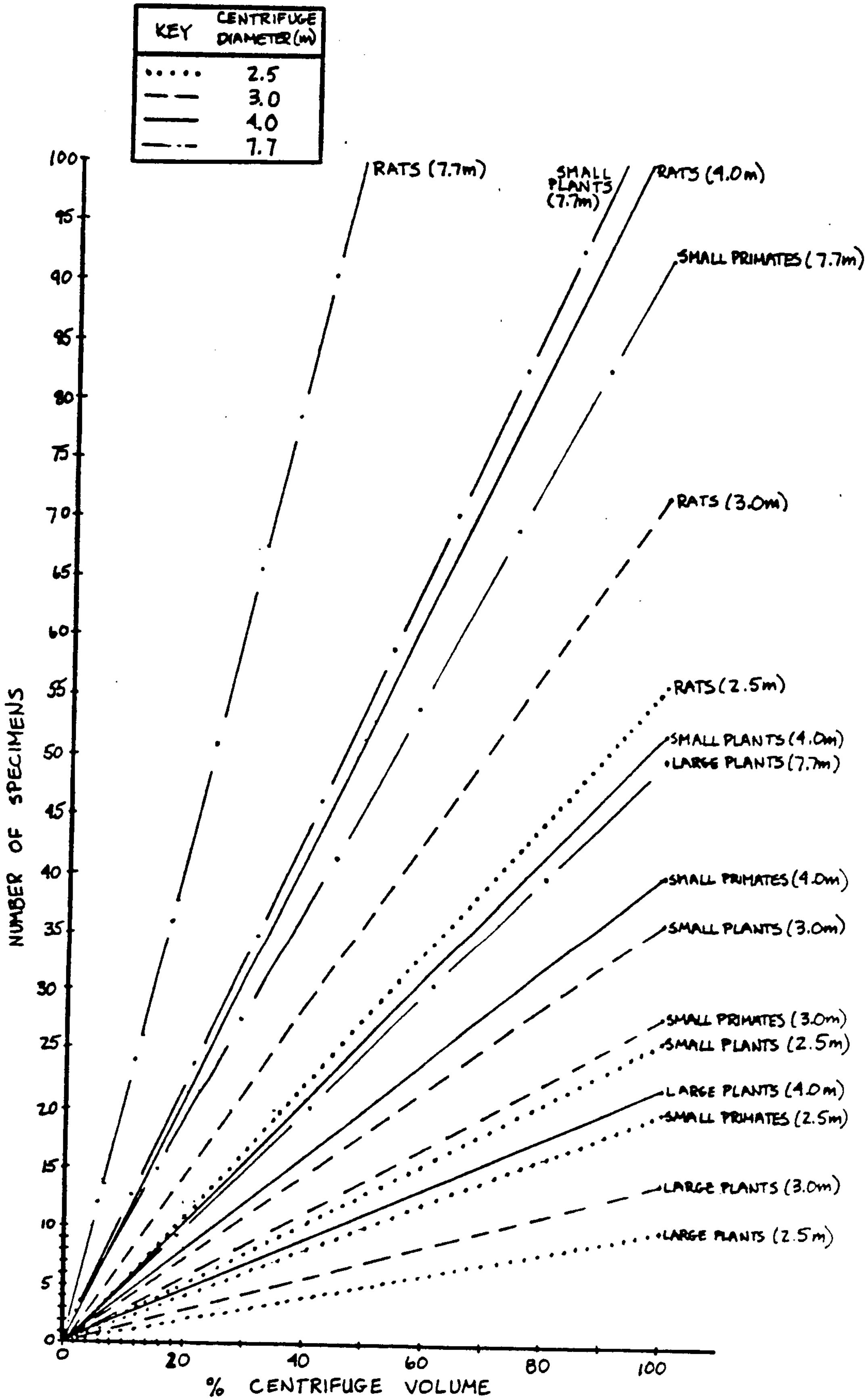
SPACE STATION

MAGNETIC BEARING TECHNICAL DATA FOR CENTRIFUGE

Lockheed

INCREASING CENTRIFUGE DIAMETER INCREASES SPECIMEN LOADING CAPACITY RESULTING IN HIGHER NUMBERS OF REPLICATE SAMPLES PER EXPERIMENTAL RUN. INCREASED CENTRIFUGE CAPACITY, THEREFORE, ENHANCES EXPERIMENT STATISTICAL PRECISION AND RELIABILITY AND FACILITATES EXPERIMENT OPERATIONS IN TERMS OF INFORMATION GAINED PER UNIT OF EXPERIMENT TIME.

SPECIMEN ACCOMMODATION ON VARIOUS DIAMETER CENTRIFUGES



SPECIMEN ACCOMMODATION ON VARIOUS DIAMETER CENTRIFUGES

SPACE STATION

CHOICE OF CENTRIFUGE MUST BE MADE WITHIN THE SPACE STATION POWER, COOLING, AND THERMAL LOAD CAPABILITIES. RESOURCE REQUIREMENTS FOR EACH CENTRIFUGE SIZE ARE SHOWN IN THE ACCOMPANYING TABLE.

CENTRIFUGE DIAMETER (METER) (ft)	VOLUME (METER^3) (ft^3)	WEIGHT (kg) (lb)	POWER (kW)			THERMAL LOAD (kW) AMBIENT AIR COOLING			THERMAL LOAD (kW) DISTRIBUTION SYSTEM COOLING		
			BEARING TYPE			BEARING TYPE			BEARING TYPE		
			BALL	AIR	MAGNETIC	BALL	AIR	MAGNETIC	BALL	AIR	MAGNETIC
2.50 8.20	4.24 149.7	424 935	3.43	3.91	5.01	2.00	1.99	3.49	1.54	2.03	1.63
3.00 9.84	6.10 215.4	610 1354	4.60	5.33	6.49	2.69	2.68	4.48	2.05	2.79	2.15
4.00 13.12	10.85 383.1	1085 2392	6.83	8.31	9.03	3.99	3.97	6.07	3.06	4.55	3.17
7.70 25.26	38.88 1374	3888 8588	14.03	18.42	21.67	8.23	8.21	15.71	6.21	10.18	6.38

SPACE STATION

CENTRIFUGE RESOURCE REQUIREMENTS

Lockheed

IN ADDITION TO MEETING THE SCIENCE REQUIREMENTS FOR THE LSRF THE CENTRIFUGE MUST BE INTEGRATED INTO THE SLM SUCH THAT NON-CENTRIFUGE LSRF OPERATIONS REMAIN UNAFFECTED BY ITS PRESENCE. MOREOVER, THE CENTRIFUGE MUST NOT SIGNIFICANTLY EFFECT CREW EGRESS IN EMERGENCY SITUATIONS AND ITS LOCATION MUST NOT PRECLUDE ON-ORBIT SERVICING AND MAINTENANCE ACTIVITIES.

CENTRIFUGE DIAMETER (METER) (ft)	CENTRIFUGE MOUNT	MODULE TRAFFIC PATTERN	MODULE VOLUME EFFICIENCY	COMMON MODULE MODIFICATION REQUIRED	DIFFICULTIES WITH ON-ORBIT INSTALLATION OR MODULE RECONFIGURATION	MODULE SHELL ACCESS	CENTRIFUGE REPAIR AND MAINTENANCE ACCESS
2.50 8.20	AXIAL	FAIR	FAIR	NONE	SOME	FAIR	FAIR
2.50 8.20	SIDE	GOOD	POOR	NONE	SOME	FAIR	FAIR
3.00 9.84	SIDE	POOR	POOR	SOME	MANY	GOOD	FAIR
4.00 13.12	AXIAL WITH CENTER PASS-THROUGH	GOOD	GOOD	MAJOR	MOST	WORST	BEST
4.00 13.12	AXIAL END MOUNT	BEST	BEST	MAJOR	MANY	WORST	WORST
7.70 25.26	AXIAL END MOUNT	BEST	BEST	MAJOR	MOST	WORST	WORST

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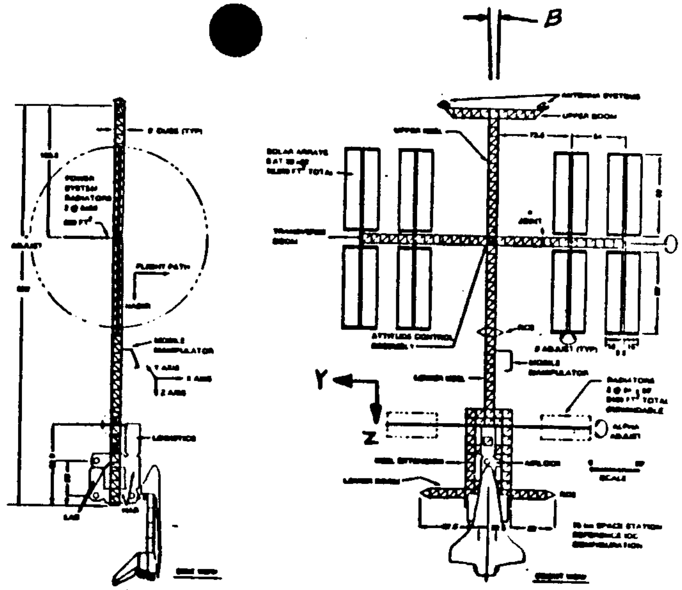
SPACE STATION

CENTRIFUGE/SCIENCE LAB MODULE INTEGRATION

Lockheed

A STRINGENT MICROGRAVITY REQUIREMENT OF 10^{-5}g MUST BE MAINTAINED FOR TECHNOLOGY DEVELOPMENT AND PLANT EXPERIMENTS IN THE LSRF. CENTRIFUGE OPERATIONS POTENTIALLY IMPACT THIS MICROGRAVITY LEVEL AND DEPENDING UPON ITS ORIENTATION, MAY INDUCE UNDESIRABLE GYROSCOPIC TORQUES ON THE ENTIRE SPACE STATION. DYNAMICS FOR LSRF CANDIDATE CENTRIFUGES ARE ILLUSTRATED ON THE FOLLOWING PAGE.



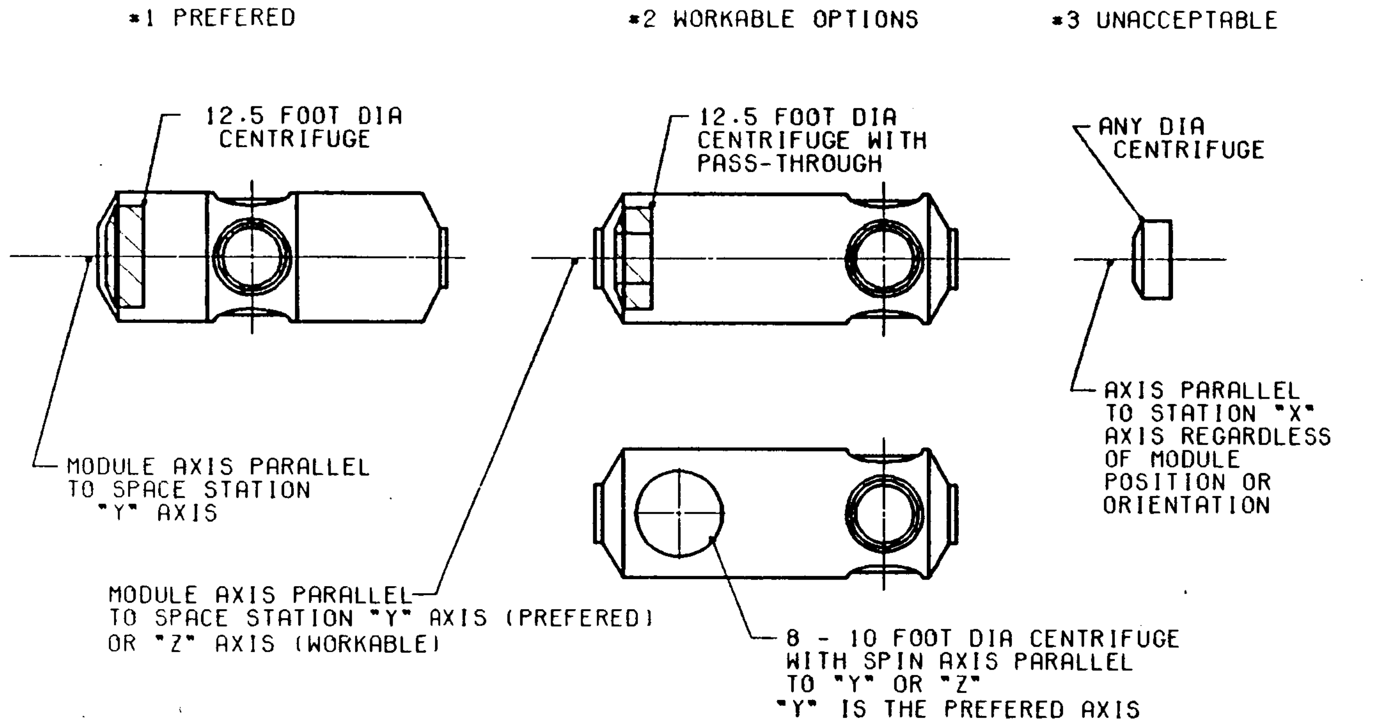
CENTRIFUGE DIAMETER (METER) (ft)	CENTRIFUGE VOLUME ($METER^3$) (ft^3)	CENTRIFUGE WEIGHT (kg) (lb)	(RADIUS OF GYRATION)^2 ($METER^2$) (ft^2)	INERTIA ($kg \cdot m^2$) ($ft \cdot lb \cdot sec^2$)	SPIN RATE (RPM) (Rad/sec) (Hz)	ANGULAR MOMENTUM ($kg \cdot m^2/sec$) ($ft \cdot lb \cdot sec$)	GYROSCOPIC TORQUE (METER-kg) (ft-lb)	TILT ANGLE β TO COUNTER GYROSCOPIC TORQUE OF "Z" AXIS CENTRIFUGE	TORQUE REQUIRED FOR 2 MIN SPIN-UP (METER-kg) (ft-lb)
2.00 6.56	3.45 121.8	345 760	0.50 5.39	17.6 127	31.3 3.28 0.53	57.7 416	0.066 0.48	0.05°	0.49 3.5
2.50 8.20	4.24 149.7	424 935	0.78 8.39	33.8 244	27.8 2.91 0.46	98.4 710	0.113 0.82	0.09°	0.82 5.9
3.00 9.84	6.10 215.4	610 1345	1.125 12.10	70.0 505	25.3 2.65 0.42	186 1340	0.214 1.55	0.17°	1.55 11.2
3.50 11.48	8.31 293.4	831 1832	1.53 16.46	130 937	23.1 2.42 0.39	314 2267	0.363 2.63	0.29°	2.62 18.9
4.00 13.12	10.85 383.1	1085 2392	2.00 21.52	221 1598	21.6 2.26 0.36	500 3610	0.579 4.19	0.46°	4.15 30.0

SPACE STATION

CENTRIFUGE DYNAMICS

Lockheed

PROPER POSITIONING OF THE CENTRIFUGE IN THE SLM IS A PRIME REQUISITE FOR MAINTAINING MICRO-G LEVELS AND MINIMIZING GYROSCOPIC TORQUES TO THE SPACE STATION. THE PREFERRED POSITION IS AN END-CONE MOUNTED 12.5 FOOT CENTRIFUGE IN A MODULE WHOSE AXIS IS PARALLEL TO THE SPACE STATION "Y" AXIS.



OF POOR QUALITY

SPACE STATION

CENTRIFUGE OPTIONS FOR THE GRAVITY GRADIENT FLIGHT MODE

Lockheed

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AN LMSC TRADE STUDY INDICATED THAT RESOURCES ARE BETTER USED BY WASHING DIRTY ANIMAL CAGES THAN RESUPPLYING CLEAN CAGES USING THE LOGISTICS MODULE. A CAGE WASHER-CONCEPT WHICH COULD SPRAY WASH, STERILIZE AND DRY SOILED CAGES IS CURRENTLY BEING DEVELOPED.

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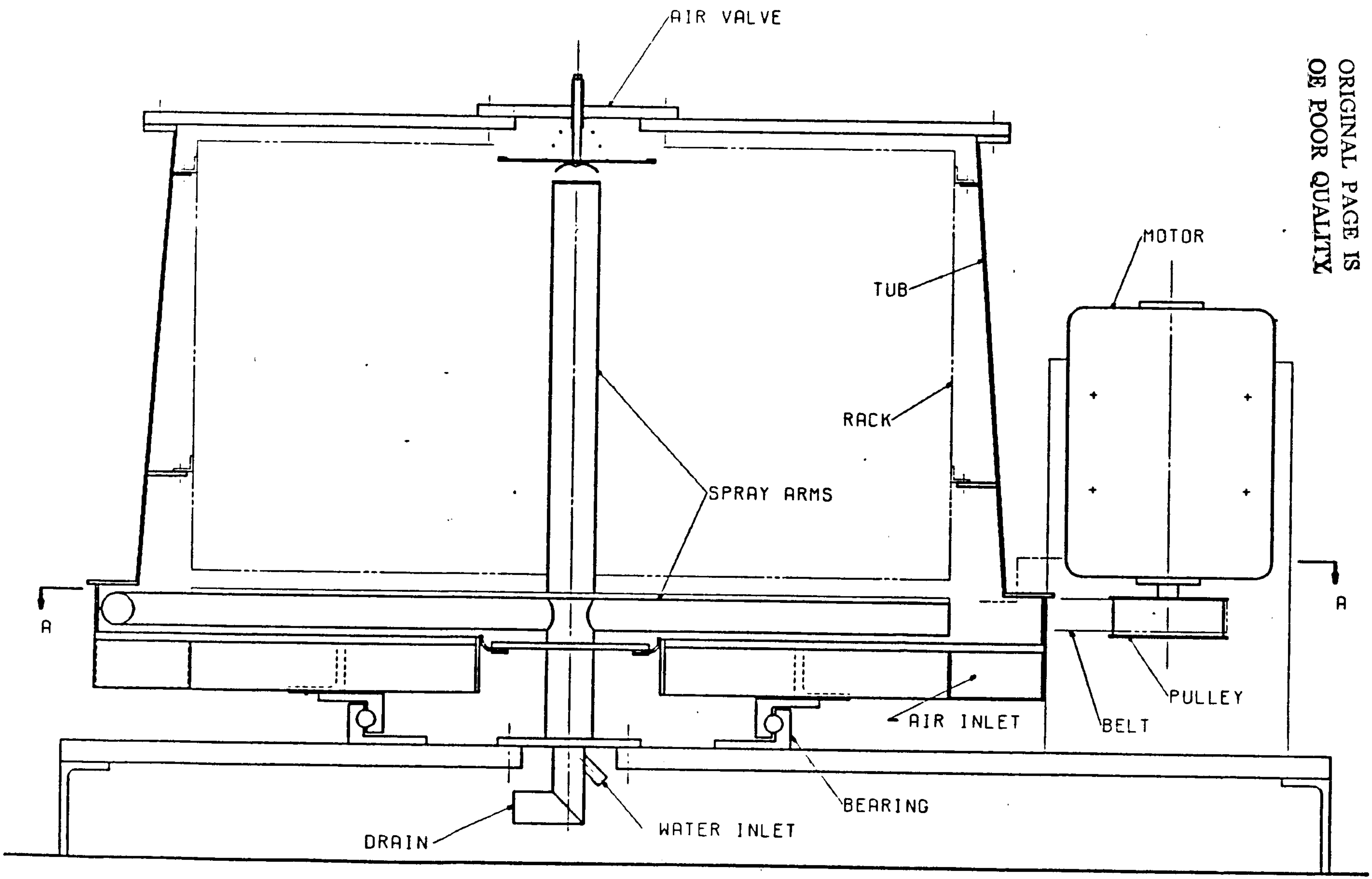
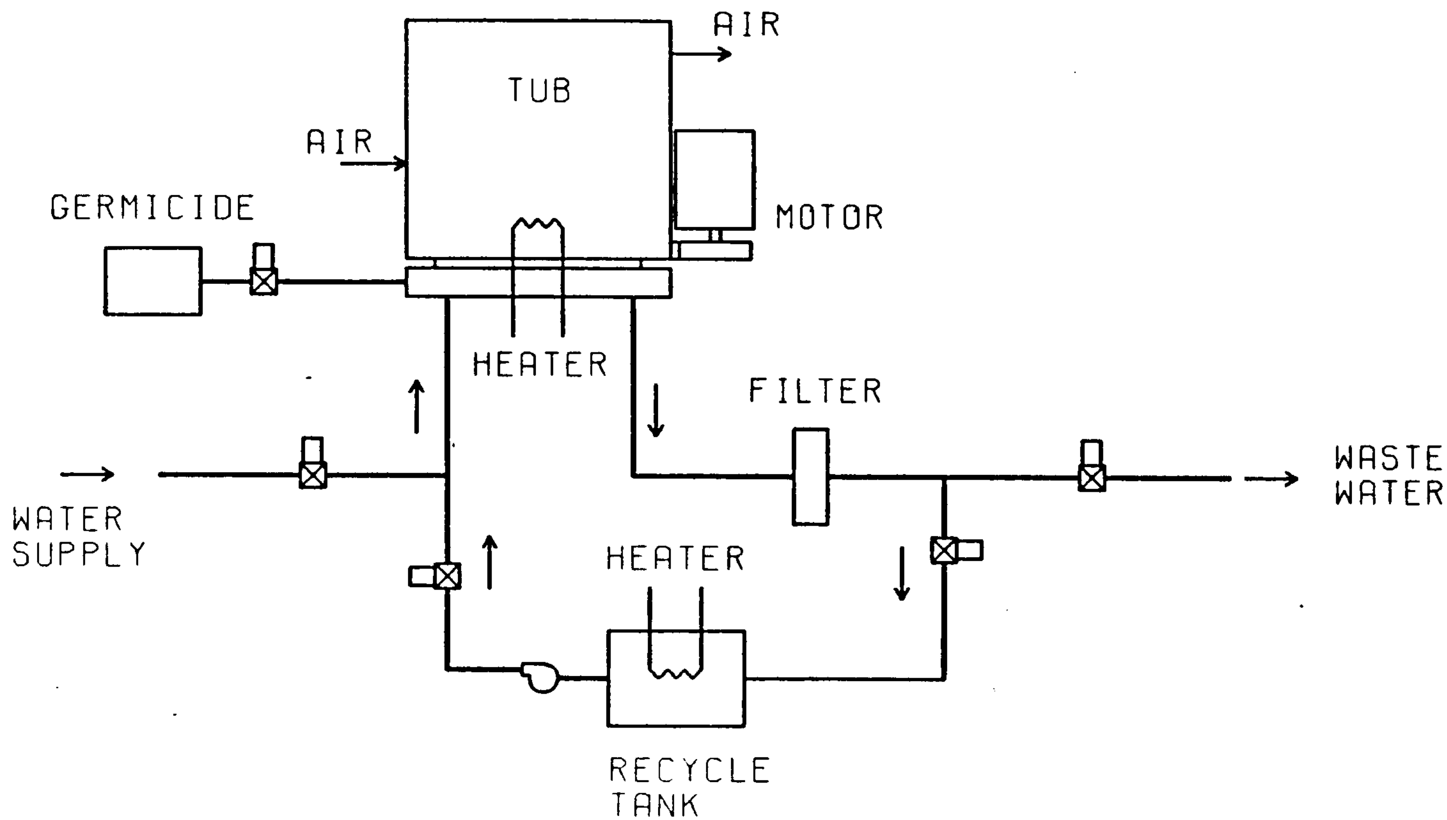


SPACE STATION

CAGE WASHER BREADBOARD CONCEPT

Lockheed

5



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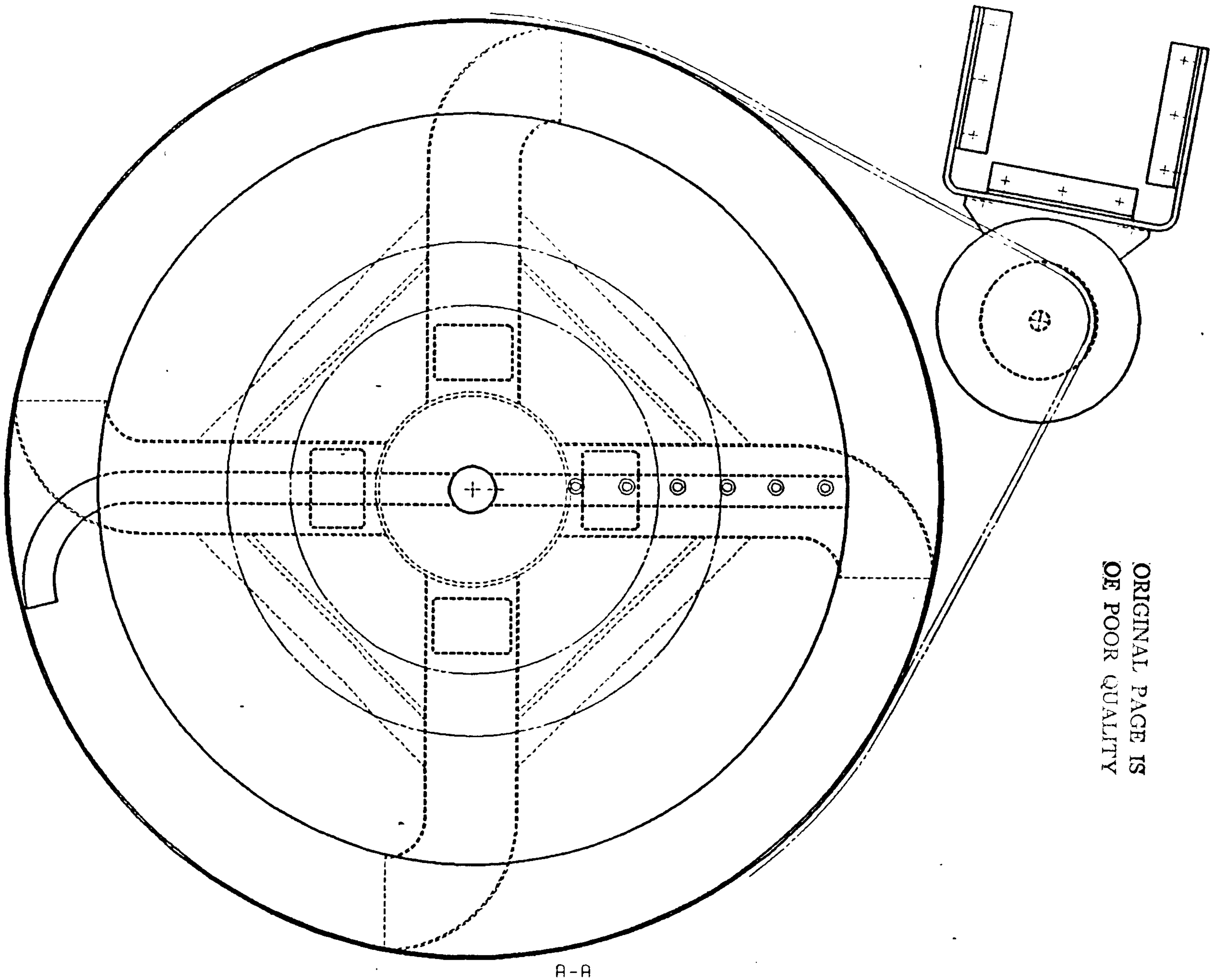
SPACE STATION

CAGE WASHER SCHEMATIC

Lockheed



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SPACE STATION

CAGE WASHER BREADBOARD - TOP VIEW

Lockheed

6

THERE ARE SEVERAL QUESTIONS REGARDING THE EFFECT OF PROLONGED WEIGHTLESSNESS ON PHYSIOLOGICAL MECHANISMS THAT POTENTIALLY EFFECTS MAN'S PERFORMANCE AND WELL-BEING IN SPACE.

QUESTIONS

- **Does Weightlessness Affect Levels of Fluid/Electrolyte Regulation Hormones?**

- **Does Prolonged Exposure to Weightlessness Severely Alter Fluid/Electrolyte Balance?**

- **Does Tissue Degeneration and Loss of Nitrogen Continue Indefinitely or Does Nitrogen Balance Reach a New Steady State?**

- **Does Weightlessness Affect the Balance of Other Nutrients?**

- **Does the Metabolic Rate Change in Response to Acute and/or Chronic Exposure to Weightlessness?**

A FIRST STEP TO ANSWERING THESE QUESTIONS IS TO PERFORM EXPERIMENTS ON NON-HUMAN VERTEBRATES IN A CONTROLLED ENVIRONMENT UNDER WEIGHTLESS CONDITIONS. THE CONTROLLED ENVIRONMENT SHALL BE CAPABLE OF PROVIDING ALL LIFE SUPPORT FUNCTIONS TO THE SPECIMENS AND BE USED FOR DATA COLLECTION AND ANALYSIS AS WELL.

REQUIREMENTS

EXPERIMENTAL SUPPORT

- **Holding Facility**
- **Food and Water**
- **Waste Management**
- **Environmental Control**

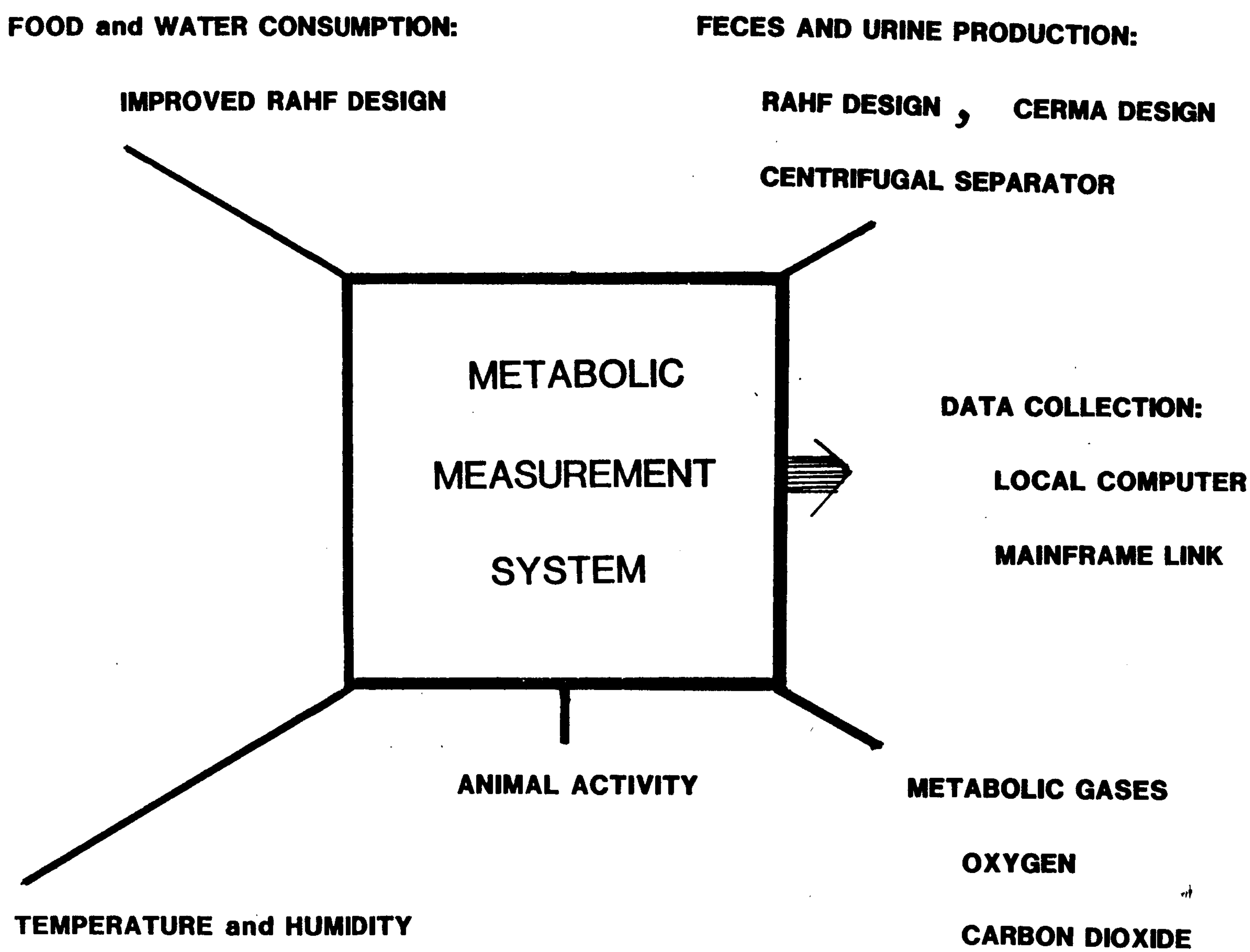
EXPERIMENTAL MEASUREMENT

- **Data Collection and Quantitation**
- **Computer Capability**

EXPERIMENTAL DESIGN

- **Protocol**

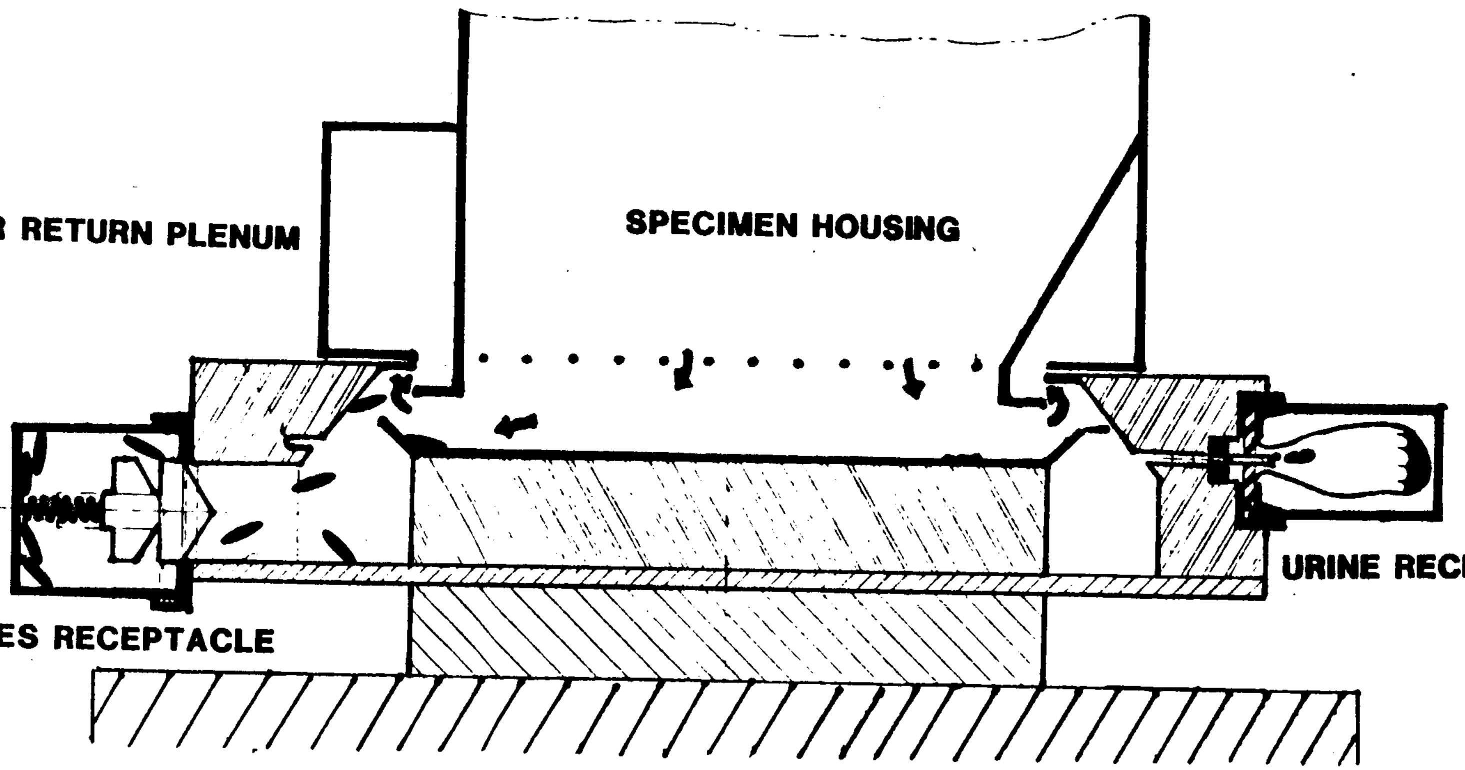
THE METABOLIC MEASUREMENT SYSTEM IS CURRENTLY UNDER DEVELOPMENT AND IS BEING DESIGNED TO MEET PREVIOUSLY DEFINED REQUIREMENTS. THE SYSTEM IS SELF-CONTAINED, PROVIDES FOOD AND WATER TO SPECIMEN(S), PROVIDES A CONTROLLED THERMAL AND ATMOSPHERIC ENVIRONMENT AND IS INTERFACED TO AN ON-BOARD COMPUTER FOR DATA ANALYSIS.



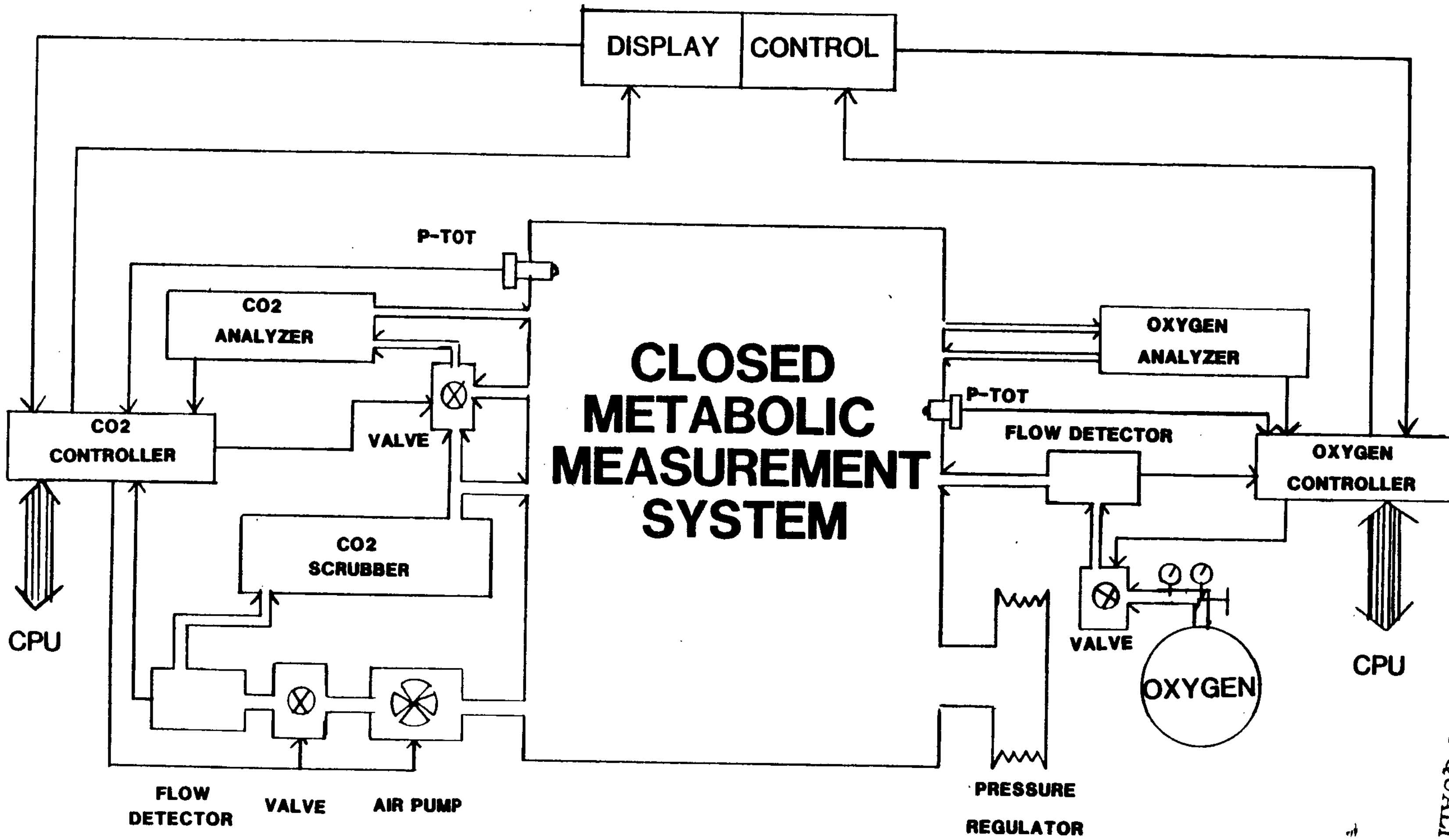
SPACE STATION ||| 3.3.2 TECHNOLOGY DEVELOPMENT REQUIREMENTS

Lockheed

THE URINE-FECES COLLECTION PORTION OF THE METABOLIC MEASUREMENT SYSTEM IS DESCRIBED IN THIS FIGURE. THIS DEVICE IMPROVES UPON PREVIOUS RESEARCH ANIMAL HOLDING FACILITY (RAHF) CONCEPTS AND UTILIZES IMPROVED TECHNOLOGY AND DESIGN BASED ON CENTRIFUGAL PRINCIPLES TO SEPERATE URINE FROM FECES AND COLLECT THEM.


AIR RETURN PLENUM
SPECIMEN HOUSING
URINE RECEPTACLE
FECES RECEPTACLE

A SCHEMATIC REPRESENTATION OF THE CLOSED CONFIGURATION ATMOSPHERIC CONTROL AND MEASUREMENT SYSTEM IS PRESENTED IN THIS FIGURE. OXYGEN CONSUMPTION AND CARBON DIOXIDE PRODUCTION ARE MEASURED AND THE ATMOSPEHRIC ENVIRONEMNT REGULATED. THIS SYSTEM IS CONSIDERABLY MORE COMPLICATED THAN THE OPEN CONFIGURATION DESCRIBED IN THE FOLLOWING FIGURE.



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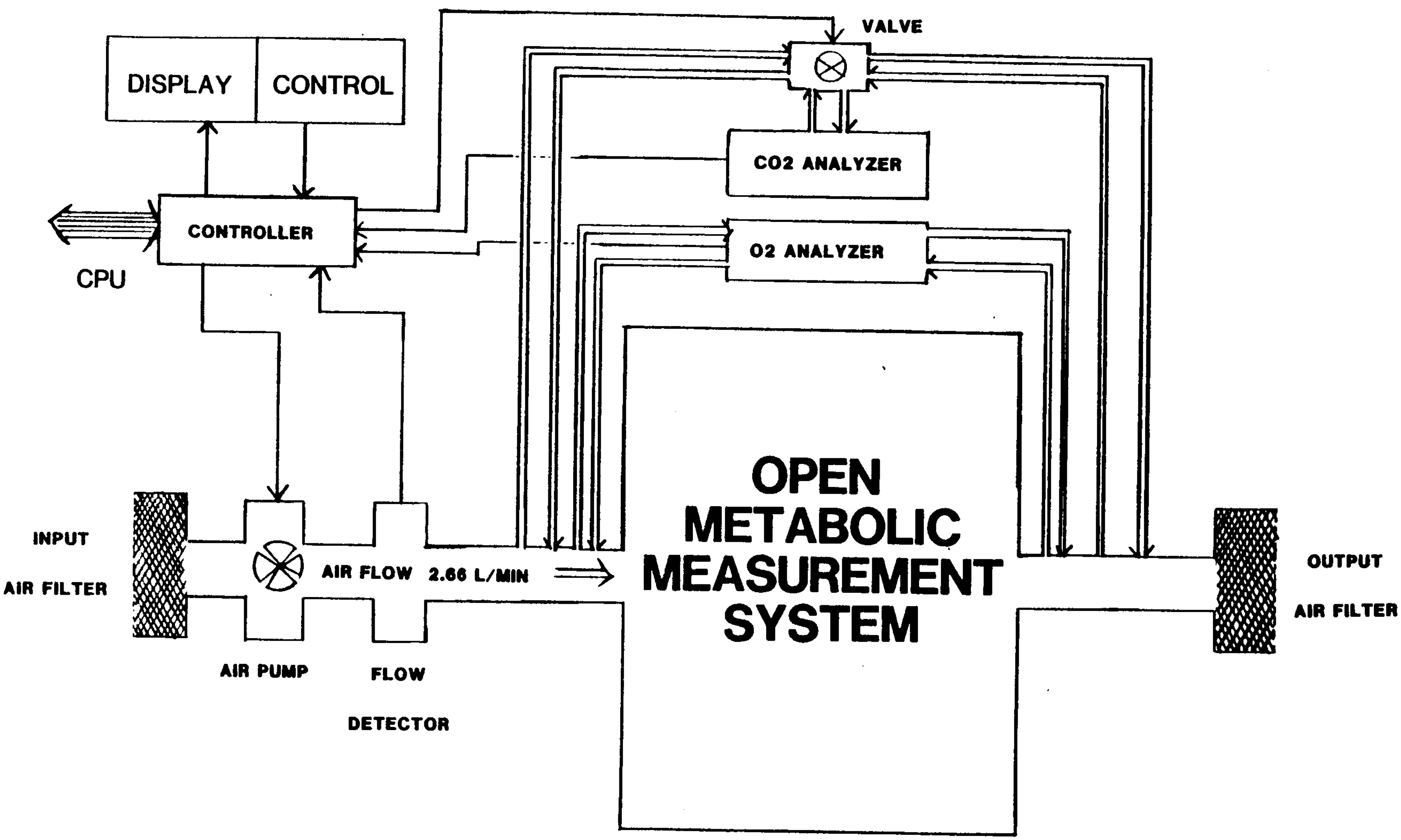
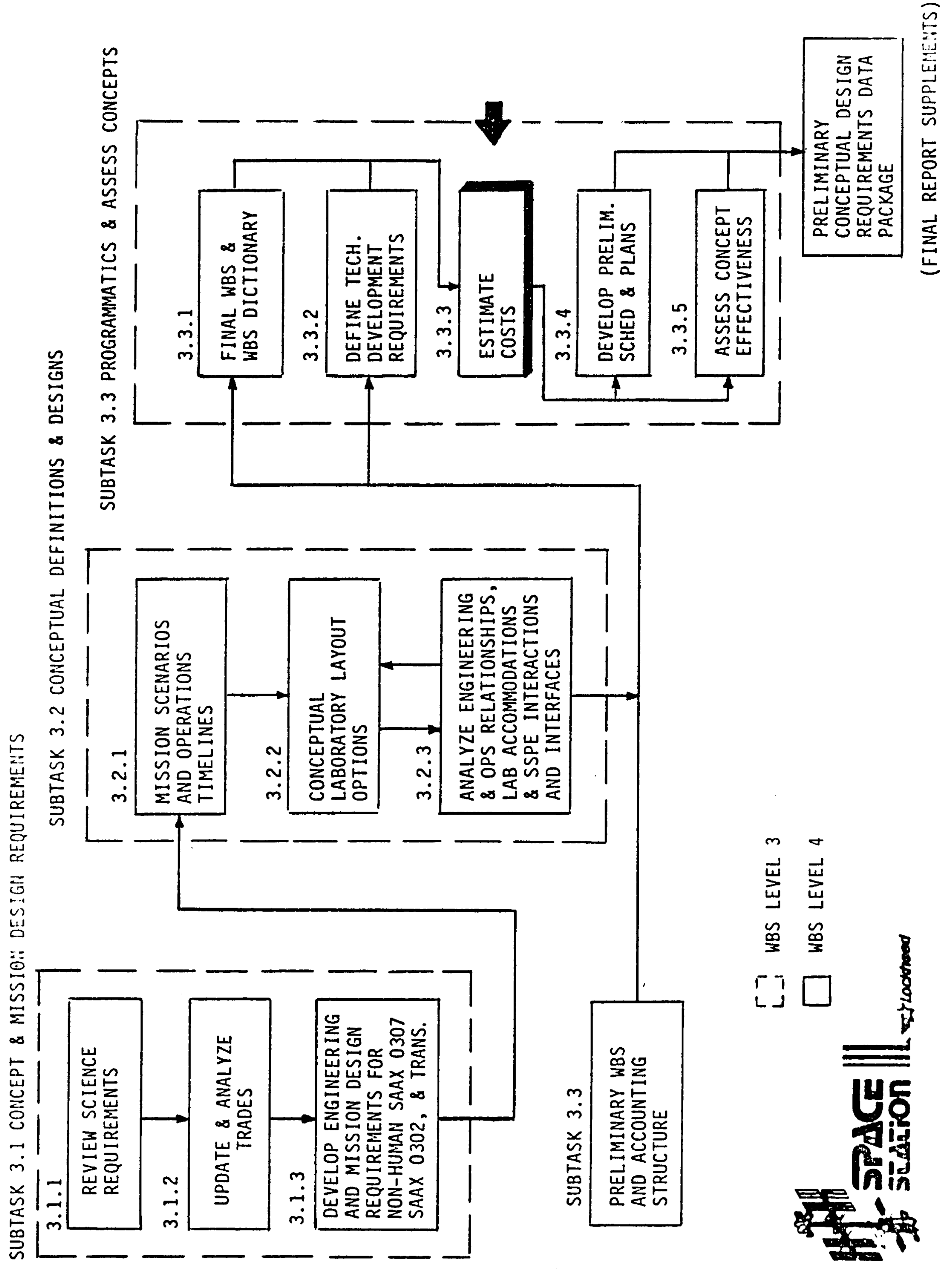
SPACE STATION

3.3.2 TECHNOLOGY DEVELOPMENT REQUIREMENTS

Lockheed

A SCHEMATIC REPRESENTATION OF THE OPEN CONFIGURATION ATMOSPHERIC CONTROL AND MEASUREMENT SYSTEM IS PRESENTED IN THIS FIGURE. OXYGEN CONSUMPTION AND CARBON DIOXIDE PRODUCTION ARE MAINTAINED. THE ATMOSPHERIC ENVIRONMENT WITHIN THE CHAMBER IS REGULATED TO WITHIN 0.5% OF THE INCOMING BLEED AIR-SUPPLY CONCENTRATION. THE COMPLEXITY AND SUPPORT OF THIS SYSTEM IS DECREASED CONSIDERABLY COMPARED TO THE CLOSED METABOLIC MEASUREMENT SYSTEM.


VALVE
DISPLAY
CONTROL
CO2 ANALYZER
CONTROLLER
O2 ANALYZER
CPU
OPEN
METABOLIC
MEASUREMENT
SYSTEM
INPUT
AIR FILTER
AIR FLOW 2.66 L/MIN
AIR PUMP
FLOW
DETECTOR
OUTPUT
AIR FILTER



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COST ESTIMATES FOR THE COMBINED LAB (SAAX 0307) AND THE DEDICATED LAB (SAAX 0302) ARE PROVIDED ON THE ACCOMPANYING CHART. THE SAAX 0307 ESTIMATE REPRESENTS THE LSRF PORTION OR ONE HALF OF THE LAB AT IOC. THE SAAX 0302 ESTIMATE IS FOR A DEDICATED ANIMAL-PLANT VIVARIUM LAB WHICH BECOMES OPERATIONAL TWO YEARS AFTER IOC. THE DDT&E COST ESTIMATE FOR SAAX 0302 IS LESS THAN DOUBLE THAN THAT FOR SAAX 0307 BECAUSE SAAX 0307 CONTAINS EXPENSIVE LAB EQUIPMENT (E.G. CENTRIFUGE) THAT WILL BE SUPPLEMENTED BY LESS EXPENSIVE VIVARIUM EQUIPMENT DURING TRANSITION TO SAAX 0302. ANNUAL OPERATING COSTS FOR SAAX 0302 ARE ESTIMATED TO DOUBLE THAT FOR SAAX 0307. DETAILS OF THE DDT&E AND ANNUAL OPERATING COSTS FOR SAAX 0307 ARE PROVIDED ON THE FOLLOWING TWO CHARTS.

OPTION	COST ($M)	
	DDT&E	ANNUAL OPS
SAAX0307	233.6	31.5
SAAX0302	309.5	63.0

DDT&E COSTS FOR SAAX 0307 ARE ESTIMATED FROM AN OUTFITTERS POINT OF VIEW AND THEREFORE ASSUME THAT THE COMMON MODULE PROVIDES ECLSS AND UTILITY RUNS FOR LSRF EQUIPMENT INTERFACE. ITEMS LISTED IN THIS CHART ARE THOSE NECESSARY TO CONVERT THE COMMON MODULE TO A FULLY OPERATIONAL LIFE SCIENCES MODULE AT IOC AND INCLUDE THE FOLLOWING:

- STRUCTURE - SECONDARY STRUCTURE IN ADDITION TO THAT PROVIDED IN THE COMMON MODULE.
- THERMAL CONTROL - ADDITIONAL RADIATORS REQUIRED FOR LSRF HEAT DISSIPATION.
- POWER - ADDITIONAL POWER STORAGE IN THE FORM OF BATTERIES AND SUPPLEMENTAL WIRING TO ACCOMMODATE ADDITIONAL POWER.
- ECLSS - CONTAMINATION CONTROL EQUIPMENT AND WASTE MANAGEMENT ITEMS IN ADDITION TO THAT PROVIDED IN THE COMMON MODULE.
- CREW ACCOMMODATIONS - RESTRAINTS, TOOL KITS, SPECIAL LIGHTING, PERSONAL HYGIENE, EMERGENCY MEDICAL KIT.
- C & DH - HARDWARE AND COMMUNICATIONS INTERFACES.
- EXTERNAL CONTAMINATION CONTROL - EFFLUENT CONTROL, WINDOW CLEANING EQUIPMENT AND SUPPLIES, SHIELDS AND COVERS.
- SYSTEM TEST H/W - EQUIPMENT USED FOR QUALIFICATION, ACCEPTANCE, AND OTHER TESTING.
- INTEGRATION, ASSEMBLY & CHECKOUT - INTEGRATION AND ASSEMBLY HARDWARE, CHECKOUT CONSOLE, DESIGN MAINTENANCE AND LIAISON AND TOOL PLANNING, DESIGN AND FABRICATION.
- PRODUCT ASSURANCE - SAFETY, RELIABILITY, QA, AND MAINTAINABILITY
- SYSTEM TEST OPERATIONS - CONDUCT SYSTEMS TEST OF ALL LABORATORY EQUIPMENT.
- FLIGHT S/W - GENERATION AND TESTING OF ALL S/W FOR INFLIGHT APPLICATION.
- GROUND LOGISTICS SUPPORT EQUIPMENT - TO CHECKOUT, HANDLE AND TRANSPORT ALL MATERIAL AND SPECIMENS DURING PREFLIGHT, INFLIGHT, AND POSTFLIGHT OPERATIONS.
- SYSTEMS ENGINEERING & INTEGRATION - H/W DEVELOPMENT PLANNING, CONFIGURATION CONTROL, MISSION ANALYSIS, I/F REQUIREMENTS, SPECIFICATIONS, ENGINEERING DATA AND ANALYSES.
- PROGRAM MANAGEMENT - PROJECT MANAGEMENT AND COORDINATION, PLANNING AND SCHEDULING, CONTROLS, SUBCONTRACTOR LIAISON, MANAGEMENT REVIEWS, AND DESIGN-TO-COST.
- GENERAL PURPOSE FACILITIES AND EQUIPMENT - EQUIPMENT AND FACILITIES TO CONDUCT AND SUPPORT LIFE SCIENCE EXPERIMENTS.
- OPERATIONS (REQUIRED ONLY DURING DDT&E) - TRAINING, ASE, LOGISTICS, MAINTENANCE AND SERVICING, MOCKUP, GROUND AND FLIGHT OPERATIONS.
- STATION EQUIPMENT - SAFE HAVEN, SECONDARY CONTROLS, WORK STATION.
- CUSTOMER ACCOMMODATION H/W - EUE, POINTING SYSTEM, OPTICAL WINDOW, SCIENTIFIC AIRLOCK, RAPID SPECIMEN RETURN CAPSULE.
- GROUND S/W - GENERATION AND TESTING OF ALL SOFTWARE REQUIRED FOR GROUND OPERATIONS.
- SPARES - INITIAL AND PRODUCTION INCLUDING BATTERIES, FILTERS AND LIGHT BULBS

DDT&E COST ($M) - SAAX0307

STRUCTURE	3.2
THERMAL CONTROL	1.3
POWER	0.7
ECLSS	15.0
CREW ACCOMMODATIONS	1.6
COMMAND AND DATA HANDLING	25.4
CONTAMINATION CONTROL (EXTERNAL)	1.0
SYSTEM TEST HARDWARE	1.8
INTEGRATION, ASSEMBLY AND CHECKOUT	4.2
PRODUCT ASSURANCE	2.3
SYSTEM TEST OPERATIONS	21.5
FLIGHT SOFTWARE	2.5
GROUND LOGISTICS SUPPORT EQUIPMENT	9.6
SYSTEM ENGINEERING AND INTEGRATION	27.9
PROGRAM MANAGEMENT	15.1
GENERAL PURPOSE FACILITIES AND EQUIPMENT	71.4
OPERATIONS	8.3
STATION EQUIPMENT	5.3
CUSTOMER ACCOMMODATION HARDWARE	5.6
GROUND SOFTWARE	7.6
SPARES	2.3
TOTAL	233.6

ANNUAL OPERATIONS COSTS ARE ESTIMATES BASED UPON PRE-LAUNCH, ON-ORBIT, AND POST-RETURN OPERATIONAL ACTIVITIES INVOLVING THE LSRF PORTION OF THE COMBINED LAB (SAAX 0307). THE ACTIVITIES INCLUDE THE FOLLOWING:

- TRAINING - TRAINING FOR 2 FULL-TIME CREW MEMBERS PLUS BACK-UP FOR EIGHT ADDITIONAL CREW MEMBERS PLUS TRAINING INSTRUCTIONS AND EFFORT FOR KEEPING TRAINING HARDWARE CURRENT.
- LOGISTICS - RESUPPLY TRANSPORTATION EQUIPMENT CHANGEOUT, SPECIMEN CONSUMABLES, MAINTENANCE OF OPERATIONS SPARES.
- AIRBORNE SUPPORT EQUIPMENT - STRUCTURAL SUPPORT EQUIPMENT, AUXILIARY POWER SUPPLIES, AUXILIARY ECLSS AND SUPPLIES.
- MAINTENANCE AND SERVICING - SERVICING AND MAINTENANCE OPERATIONS ON-ORBIT AND ON GROUND (E.G., CHANGEOUT AND MAINTENANCE OF ORU'S AND LRU'S).
- MOCKUPS - MAINTAINING MOCKUPS.
- GROUND OPERATIONS - RAPID SPECIMEN RECOVERY, CONFIGURATION MANAGEMENT AND SUSTAINING ENGINEERING QUALITY ASSURANCE.
- FLIGHT OPERATIONS - CREW TIME AND SCHEDULING.
- RECOVERY - END-OF-LIFE DISPOSAL.
- PROGRAM MANAGEMENT - OVERALL MANAGEMENT AND COORDINATION OF OPERATIONS ACTIVITIES.

ANNUAL OPERATIONS COST ($M)

SAAX0307

TRAINING	1.2
LOGISTICS	18.5
AIRBORNE SUPPORT EQUIPMENT	0.1
MAINTENANCE AND SERVICING	2.5
MOCKUPS	0.1
GROUND OPERATIONS	3.4
FLIGHT OPERATIONS	4.2
RECOVERY (END-OF-LIFE DISPOSAL)	TBD
PROGRAM MANAGEMENT	1.5
TOTAL	31.5

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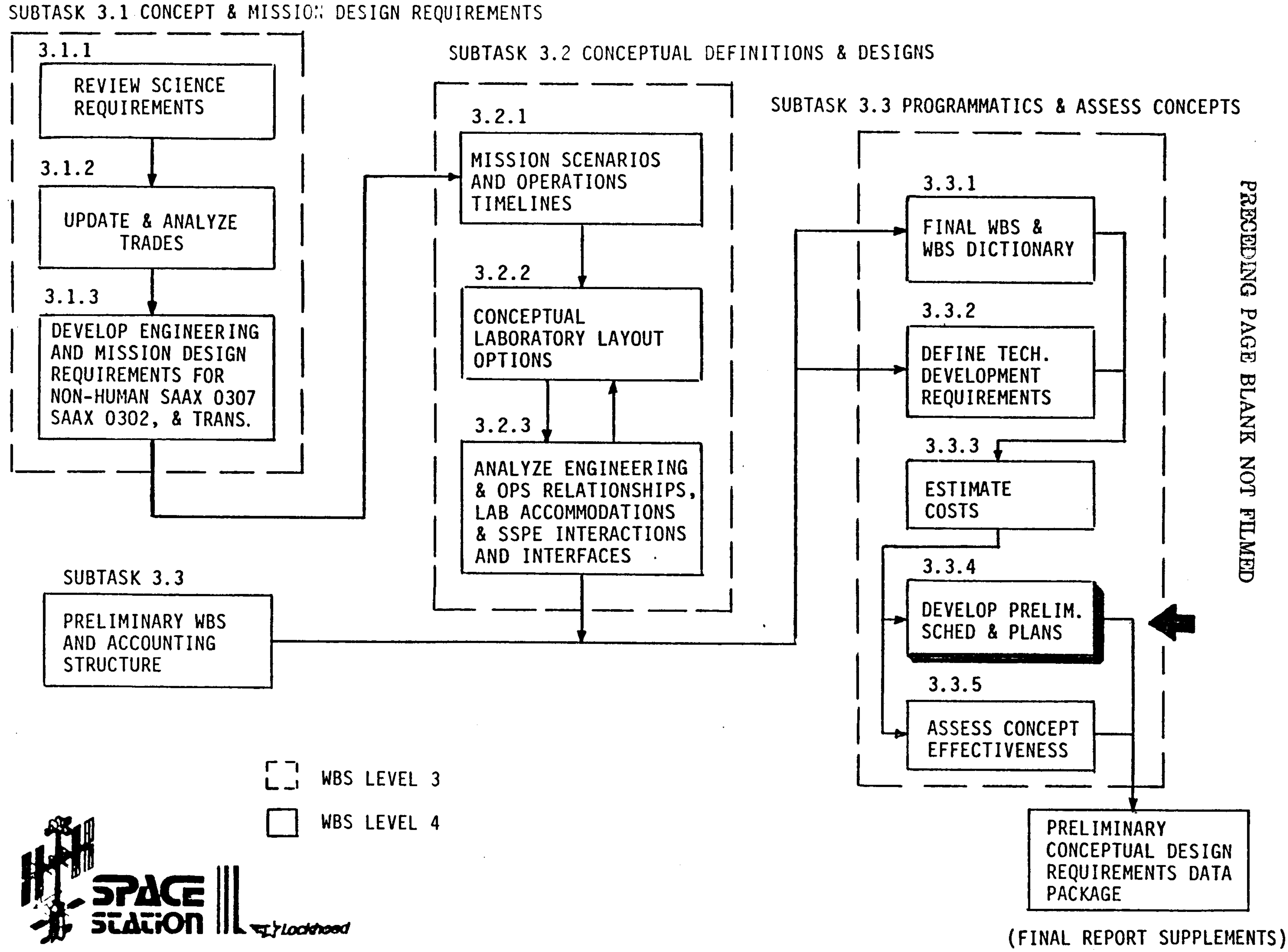


THE LSRF PROGRAM PLAN ENCOMPASSES A PHASED APPROACH, CONSISTENT WITH SPACE STATION PHASING, TO ACCOMPLISH THE REQUIREMENTS DEFINITION, DESIGN, DEVELOPMENT, ASSEMBLY, VERIFICATION, INTEGRATION AND ALL ASPECTS OF MISSION SUPPORT. THE PURPOSE OF THE PLAN IS TO (1) PROVIDE A COMPREHENSIVE PLAN FOR DEVELOPING THE LSRF FOR INCLUSION IN SPACE STATION; (2) HELP ESTABLISH NECESSARY RESOURCES FOR LSRF; (3) SUMMARIZE MANAGEMENT AND SUPPORTING RESPONSIBILITIES; (4) SUMMARIZE IMPLEMENTATION OF KEY DEVELOPMENT ACTIVITIES; AND (5) IDENTIFY INTERFACES NECESSARY FOR CONDUCTING ALL PROJECT ELEMENTS.

- PROVIDES A COMPREHENSIVE PROJECT PLAN FOR DEVELOPING THE LSRF FOR INCLUSION IN SPACE STATION
- AIDS IN ESTABLISHING NECESSARY RESOURCES FOR LSRF
- SUMMARIZES MANAGEMENT AND SUPPORTING RESPONSIBILITIES
- SUMMARIZES IMPLEMENTATION OF KEY DEVELOPMENT ACTIVITIES
- IDENTIFIES INTERFACES NECESSARY FOR CONDUCTING ALL PROJECT ELEMENTS

THE LSRF PROGRAM PLAN ADDRESSES EACH OF THE FOLLOWING: THE LSRF CONCEPT IN TERMS OF SCIENCE MANAGEMENT, DEVELOPMENT AND IMPLEMENTATION ENGINEERING, LSRF OPERATION AND MISSION PLANNING, EQUIPMENT CHANGEOUT AND RESUPPLY AND TRAINING; PROJECT SUMMARY OF ACTIVITIES ASSOCIATED WITH LSRF DEVELOPMENTAL PHASES; AND LSRF PROJECT SCHEDULES THAT ARE PHASED WITH THE OVERALL SS SCHEDULE.

- LSRF CONCEPT IN TERMS OF INVESTIGATIONS SELECTION (SCIENCE MANAGEMENT); DEVELOPMENT AND IMPLEMENTATION ENGINEERING; LSRF OPERATIONS INCLUDING FOLLOW-ON MISSION PLANNING, EQUIPMENT CHANGEOUT AND RESUPPLY; AND TRAINING
- PROJECT SUMMARY PRESENTING ACTIVITIES ASSOCIATED WITH LSRF DEVELOPMENTAL PHASES
- PROJECT SCHEDULES ENCOMPASSING OVERALL SPACE STATION SCHEDULE INCLUDING KEY DRIVING MILESTONES

THE LSRF PROJECT PLAN ENCOMPASSES THOSE BASELINE CONCEPTS NECESSARY FOR THE ORDERLY DEVELOPMENT, OPERATION AND MAINTENANCE OF AN ORBITING LSRF. THESE CONCEPTS INCLUDE:

SCIENCE MANAGEMENT - ENTAILS THE CREATION OF A LSRF REQUIREMENTS DOCUMENT WHICH DOCUMENTS NEW SCIENCE REQUIREMENTS AND EXPERIMENTS WHICH ARE SUBSEQUENTLY USED TO DEVELOP EXPERIMENTAL PROTOCOLS AND A LSRF DATABASE.

DEVELOPMENT AND IMPLEMENTATION ENGINEERING/ - CREATES A PRELIMINARY ENGINEERING/OPERATIONS DOCUMENT CONTAINING EQUIPMENT OPERATING PARAMETERS, AND IOC MISSION ENGINEERING OPERATIONS SPECIFICATION MAXIMIZING THE NUMBER OF PRIORITY INVESTIGATIONS POSSIBLE, DESIGN, DEVELOPMENT, TEST AND DELIVERY OF LSRF COMPONENTS TO KSC AND DEVELOPMENT OF LSRF SUPPORT FACILITIES.

OPERATIONS ACTIVITIES - ENCOMPASSING TRAINING ON LABORATORY START-UP PROCEDURES, EQUIPMENT CHANGE-OUT, ON ORBIT MAINTENANCE, EXPERIMENT PROTOCOL, DATA COLLECTION AND LOGISTICS, ON-ORBIT OPERATIONS AND DATA PROCESSING, GROUND MISSION SUPPORT PLANNING AND SCHEDULING.

- o SCIENCE MANAGEMENT
  - MAINTAIN LSRF REQUIREMENTS DOCUMENT
  - DOCUMENT NEW SCIENCE REQUIREMENTS
  - ESTABLISH LSRF DATABASE
  - DETERMINE IOC EXPERIMENTS
  - DEVELOP DETAILED EXPERIMENT PROTOCOLS
- o DEVELOPMENT AND IMPLEMENTATION ENGINEERING
  - PRELIMINARY ENGINEERING/OPERATIONS DOCUMENT
  - IOC MISSION ENGINEERING/OPERATION SPEC
  - DESIGN, DEVELOPMENT AND TEST
  - FACILITIES DEVELOPMENT
- o OPERATIONS
  - TRAINING
  - ON-ORBIT OPERATIONS AND DATA PROCESSING
  - GROUND MISSION SUPPORT
  - PLANNING AND SCHEDULING
  - EQUIPMENT CHANGEOUT AND SUPPLY

CONDUCT OF THE LSRF PROJECT IS STRUCTURED REASONABLY CONSISTENT WITH PHASED PROJECT PLANNING GUIDELINES UTILIZING PHASE A FOR PRELIMINARY REQUIREMENTS AND CONCEPT DEFINITION; PHASE B, REQUIREMENTS DEFINITION, PRELIMINARY DESIGN, AND DEVELOPMENT PLANNING; PHASE C, DEVELOPMENT, TESTING, FINAL DESIGN, AND FLIGHT UNIT PRELIMINARY PLANNING, AND PHASE D, FLIGHT UNIT MANUFACTURE, FLIGHT CERTIFICATION AND OPERATIONAL SUPPORT. CLOSE COORDINATION WITH THE SPACE STATION OFFICE AND OTHER PERTINENT PARTICIPANTS WILL BE MAINTAINED THROUGHOUT ALL PROJECT PHASES TO ASSURE INTERFACE COMPATIBILITY BETWEEN THE LSRF AND THE COMMON MODULE, AND TO OPTIMIZE OPERATIONAL COMPATIBILITY WITH THE OVERALL SPACE STATION.

- o PHASE A - CONCEPTUAL DESIGN AND PROGRAMMATICS STUDIES
- o PHASE B - REQUIREMENTS DEFINITION, PRELIMINARY DESIGN AND DEVELOPMENT PLANNNG
- o PHASE C - SYSTEM DEVELOPMENT, TESTING, FINAL DESIGN, FLIGHT UNIT PRELIMINARY PLANNING
- o PHASE D - FLIGHT UNIT PRODUCTION, CERTIFICATION AND OPERATIONAL SUPPORT

LSRF PROJECT PLAN SCHEDULES ARE STRUCTURED TO: BE CONSISTENT WITH KEY MILESTONES OF THE SPACE STATION, PROVIDE ADEQUATE FLEXIBILITY TO FACILITATE SYNCHRONIZATION WITH CHANGES IN SPACE STATION SCHEDULES, FORM THE BASIS FOR PLANNING RESOURCE REQUIREMENTS AND PROVIDE BASIC SRUCTURE FOR PLANNING PROJECT IMPLEMENTATION IN MORE DETAIL.

- STRUCTURED CONSISTENT WITH KEY MILESTONES OF THE SPACE STATION DEVELOPMENT SCHEDULE

- ADEQUATE FLEXIBILITY TO FACILITATE SYNCHRONIZATION WITH CHANGES IN SPACE STATION SCHEDULES

- FORM THE BASIS FOR PLANNING RESOURCE REQUIREMENTS AND PROVIDE BASIC STRUCTURE FOR PLANNING PROJECT IMPLEMENTATION IN MORE DETAIL

SPACE STATION

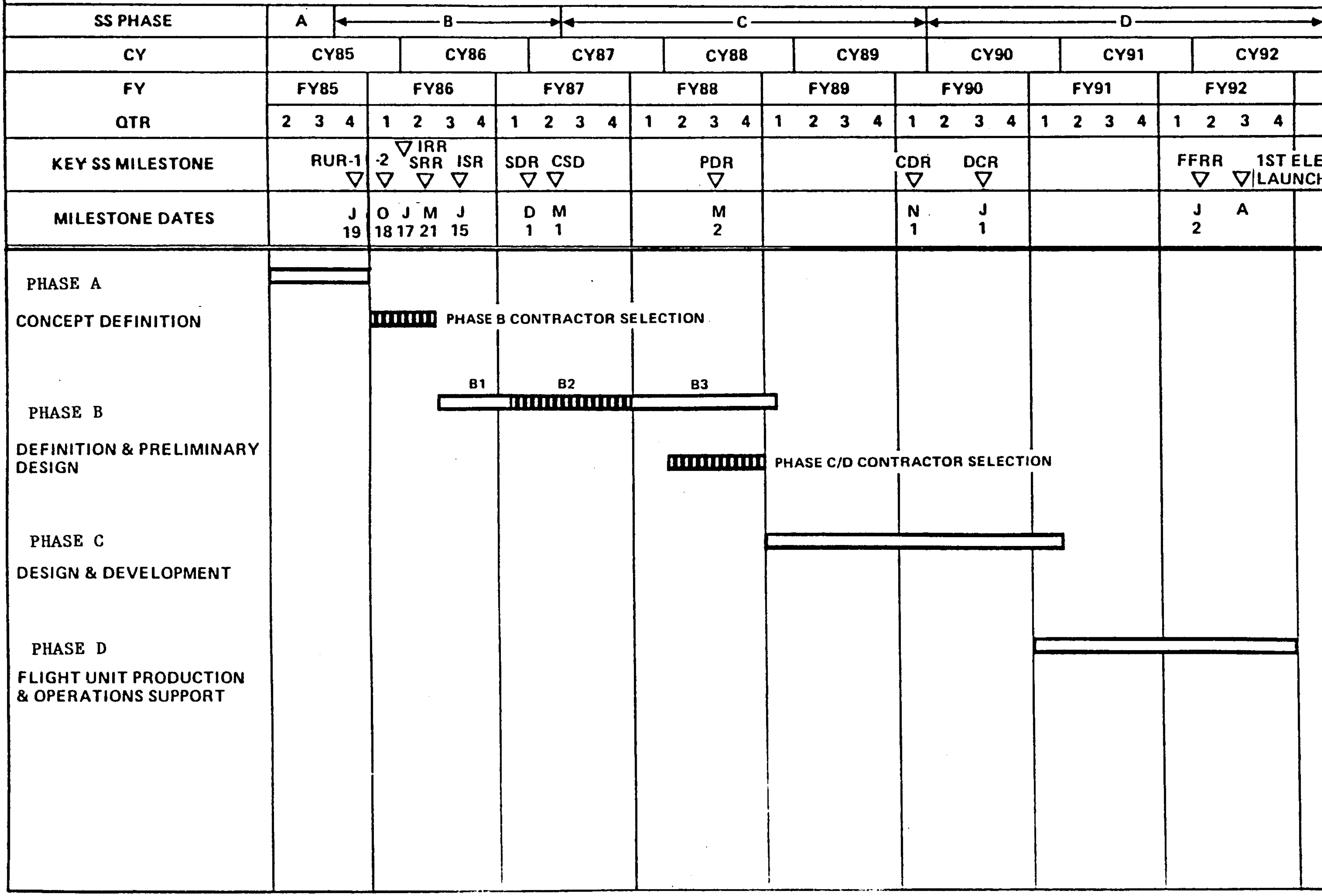
LSRF PROJECT PLAN SCHEDULES

Lockheed

THE LSRF SUMMARY IOC SCHEDULE TIME PHASES LSRF DESIGN AND DEVELOPMENT ACTIVITIES TO MEET KEY SPACE STATION MILESTONES THEREBY ENSURING THAT LSRF REQUIREMENTS ARE INTEGRATED IN CONCERT WITH OVERALL SPACE STATION DEVELOPMENT. DETAILED SCHEDULES FOR PHASES B, C, & D FOLLOW.

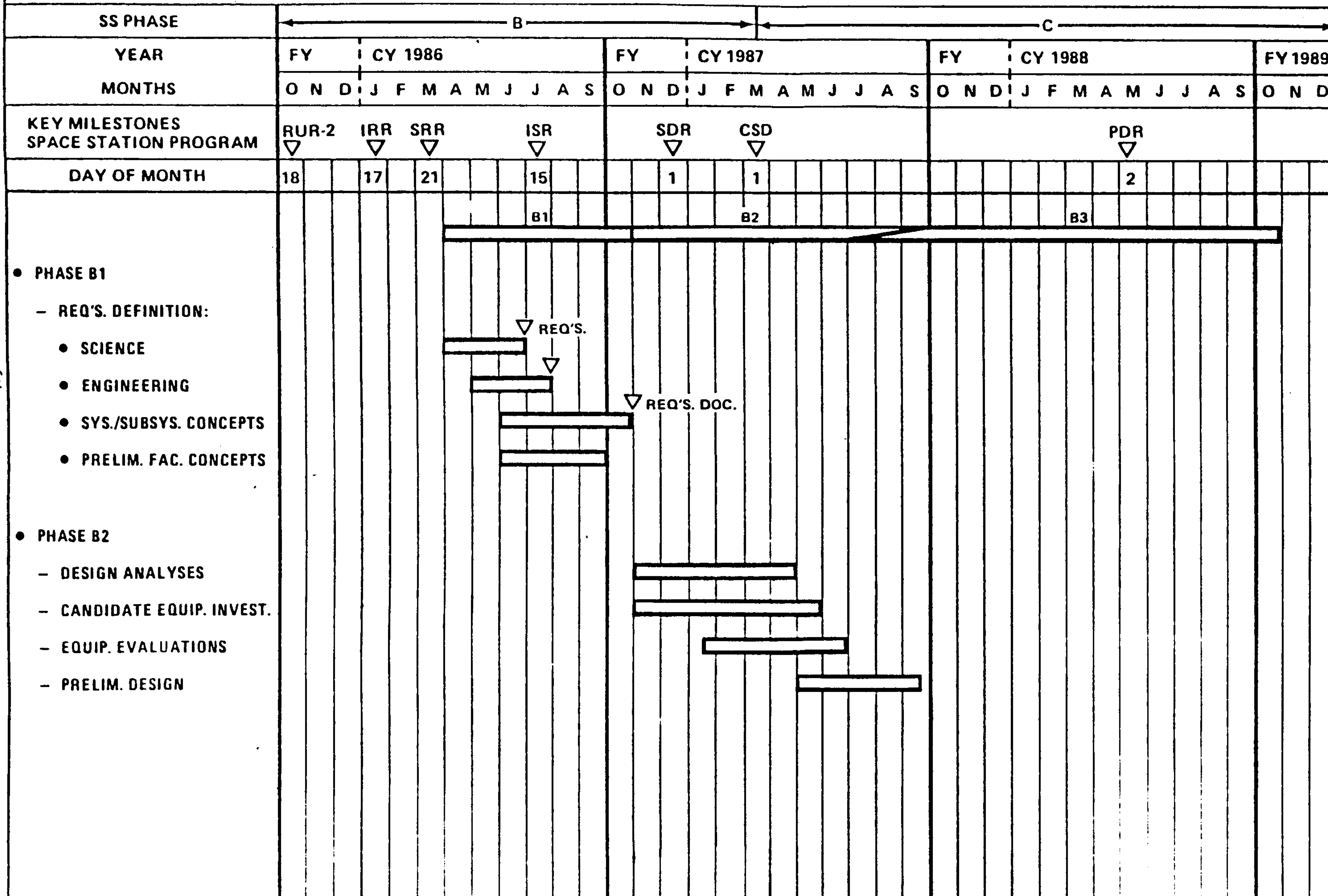
SPACE STATION LIFE SCIENCE RESEARCH FACILITY

SUMMARY SCHEDULE (IOC)



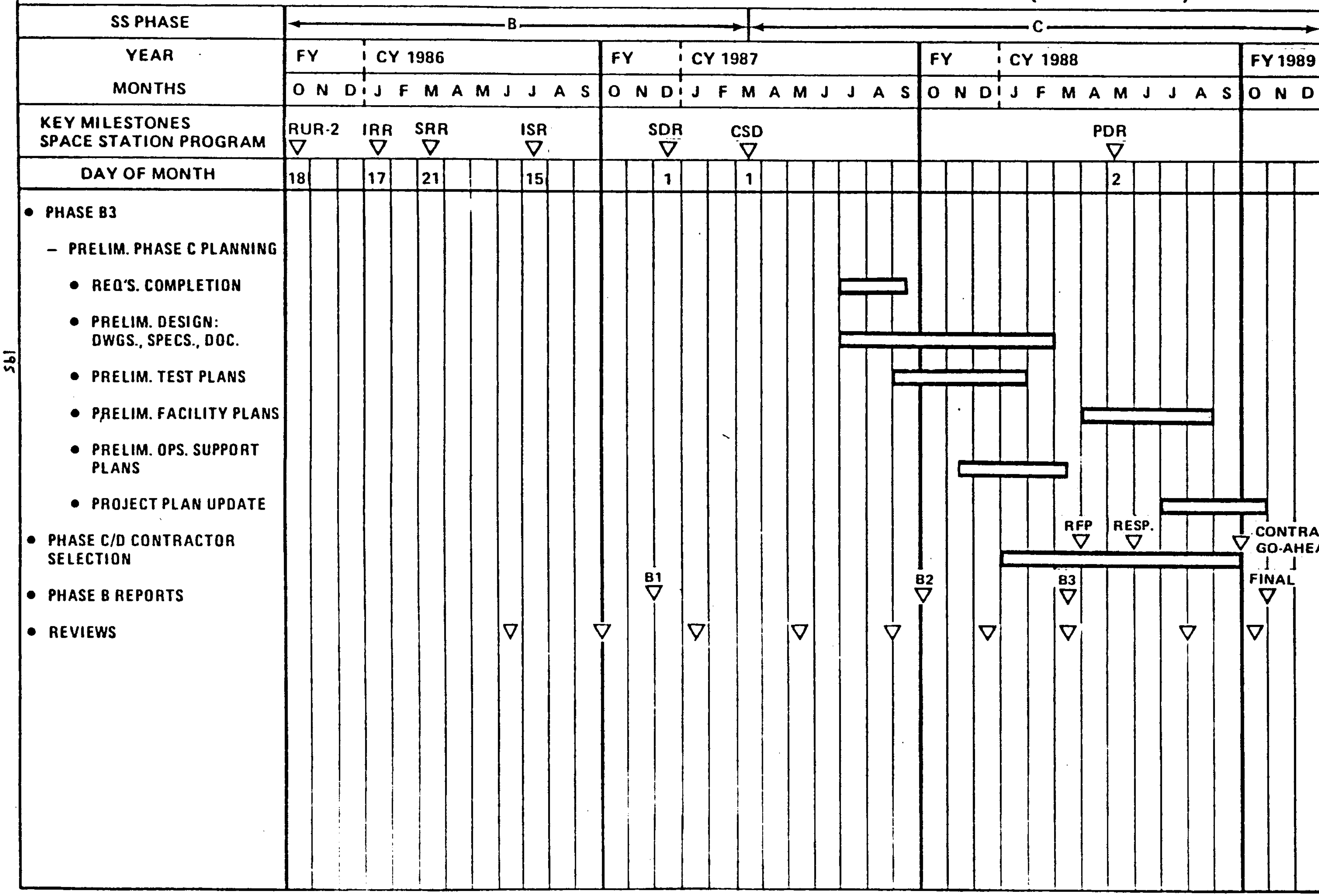
SPACE STATION LIFE SCIENCE RESEARCH FACILITY

PHASE B – REQ'S. DEF./PRELIM. DESIGN/DEV. PLANNING



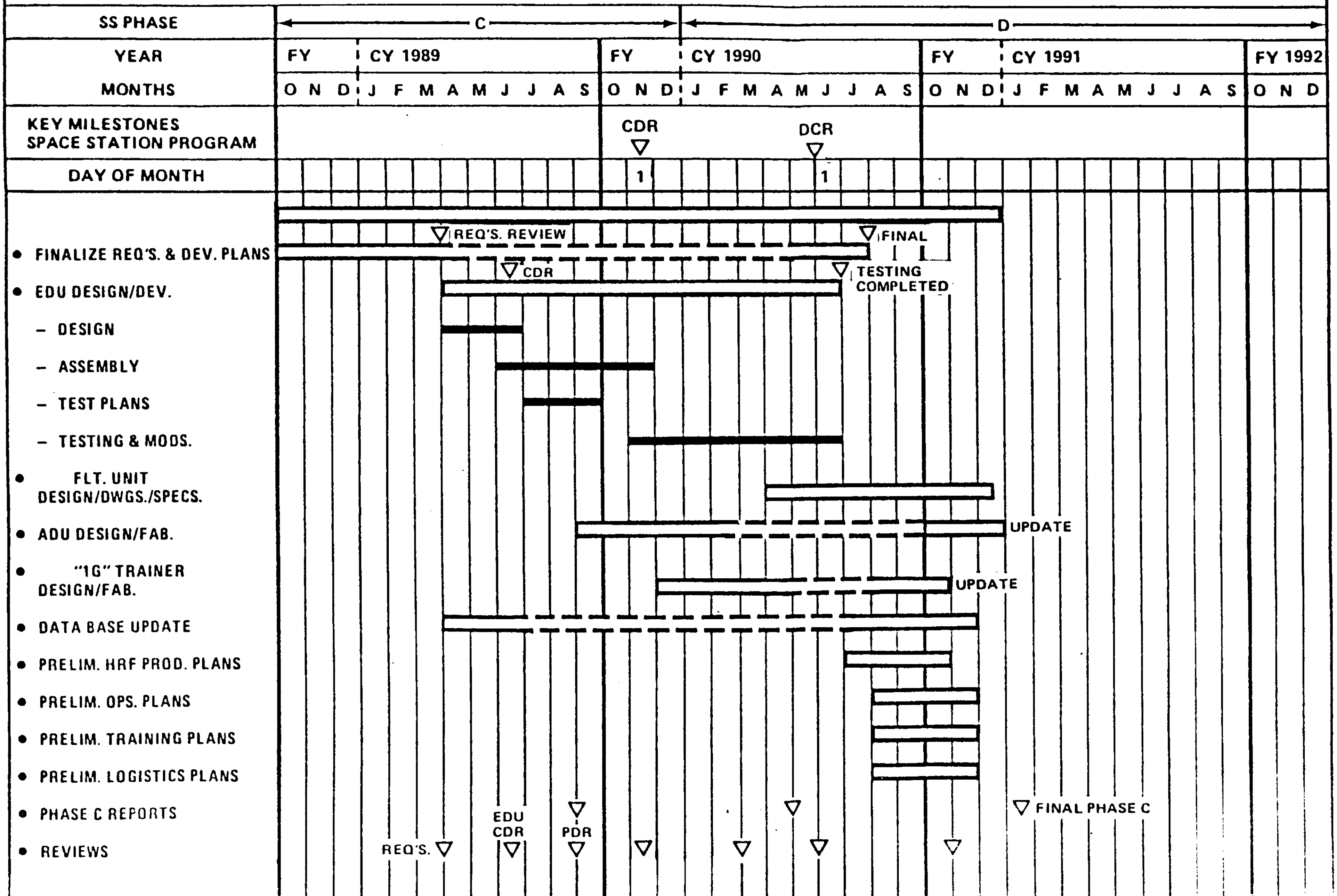
SPACE STATION LIFE SCIENCE RESEARCH FACILILTY

PHASE B – REQ'S. DEF./PRELIM. DESIGN/DEV. PLANNING (Concluded)



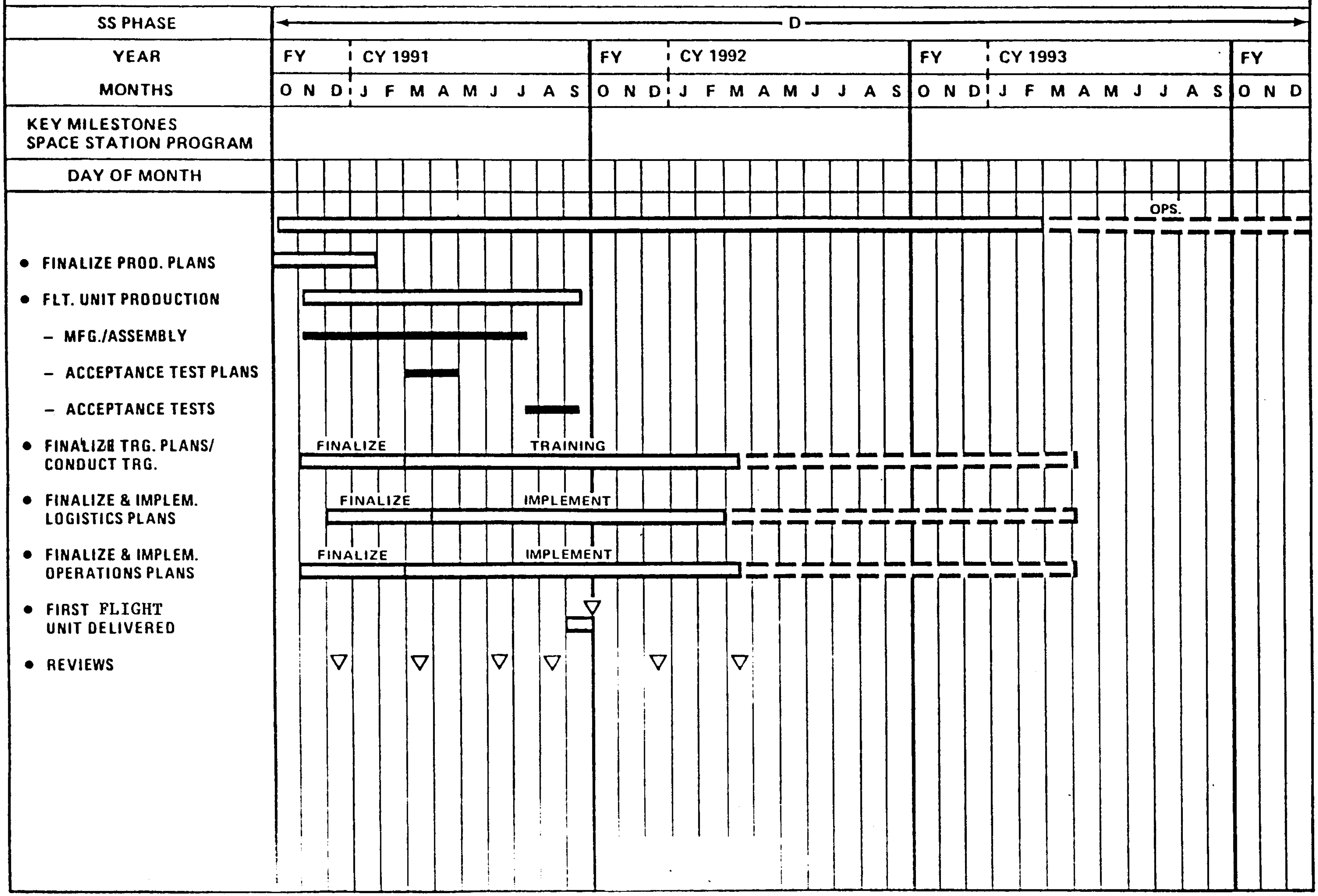
SPACE STATION LIFE SCIENCE RESEARCH FACILITY

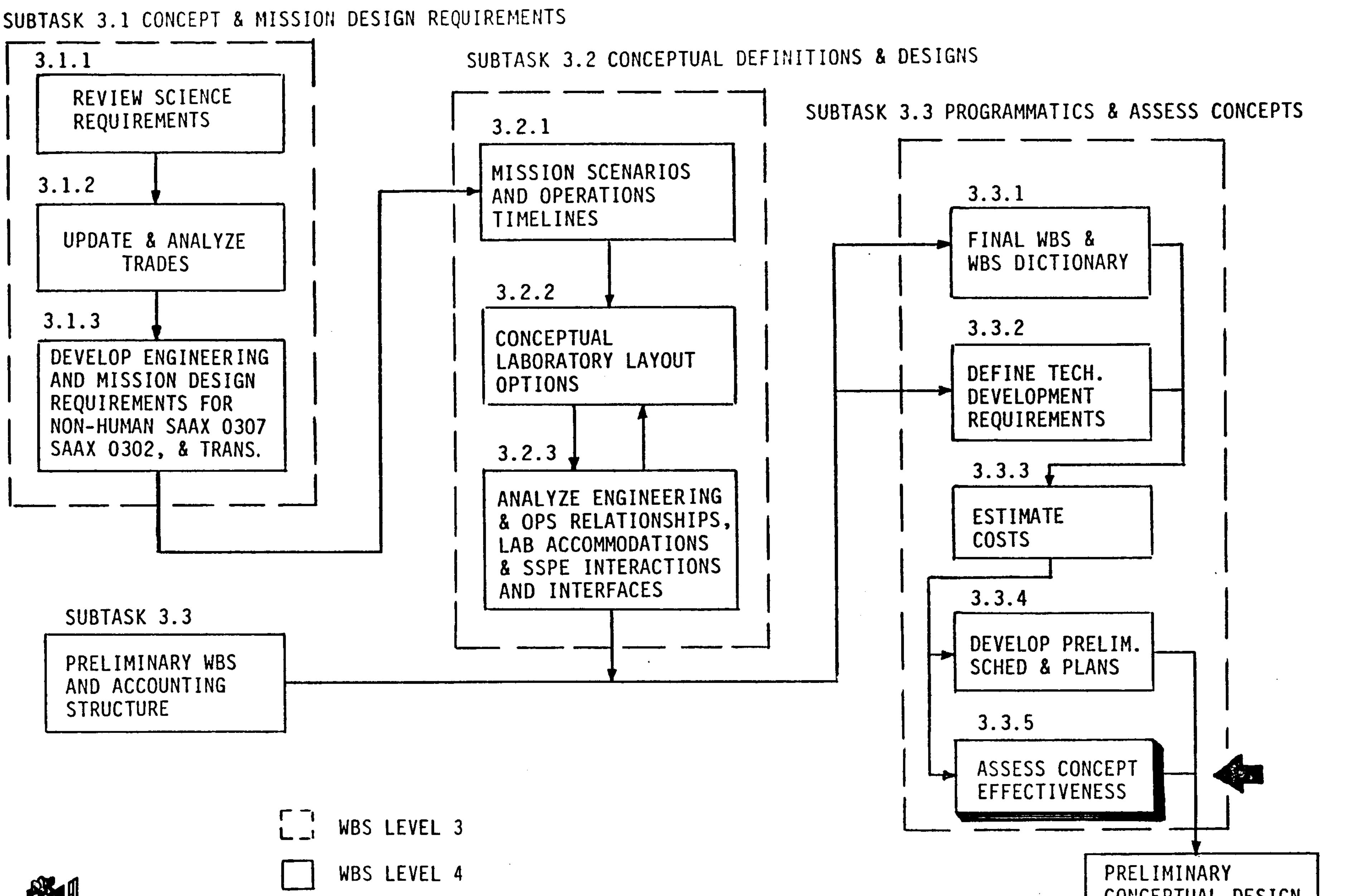
PHASE C – DEVELOPMENT, TESTING, FINAL DESIGN, PRELIM. PROD. PLANNING



SPACE STATION LIFE SCIENCE RESEARCH FACILITY

PHASE D – FLT. UNIT PRODUCTION/CERT./OPS. SUPPORT





SPACE STATION

Lockheed

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TRANSITIONING FROM THE COMBINED LABORATORY (SAAX 0307) TO THE DEDICATED PLANT-ANIMAL LAB (SAAX 0302) SHOULD MINIMIZE EQUIPMENT CHANGEOUT TO THE MAXIMUM EXTENT PRACTICABLE. GIVEN THIS OPERATIONAL CONSTRAINT AND ASSUMING THAT THE COMBINED LAB CONTAINS A CENTRIFUGE, IT IS RECOMMENDED THAT THE COMBINED LAB BECOME THE DEDICATED ANIMAL-PLANT LAB LEAVING THE CENTRIFUGE IN PLACE. THE NEW MODULE THEN BECOMES THE HUMAN RESEARCH FACILITY.

TRANSITION DISCUSSION

- ASSUME FIRST SLM (SAAX 0307) CONTAINS A SPECIMEN CENTRIFUGE
- AT TRANSITION TO SAAX 0302, NEW MODULE TO ORBIT
- IF NEW MODULE IS TO BECOME ANIMAL AND PLANT FACILITY, CENTRIFUGE WOULD HAVE TO BE DISMANTLED AND MOVED FROM FIRST MODULE TO NEW MODULE, OR LEFT IN WHAT HAS BECOME THE HUMAN RESEARCH FACILITY
- MORE LOGICAL TO LEAVE CENTRIFUGE IN FIRST MODULE, WHICH BECOMES ANIMAL AND PLANT FACILITY. NEW MODULE THEN BECOMES HUMAN RESEARCH FACILITY.
- BEST TO HAVE LARGE CENTRIFUGE, OR ONE EASILY ENLARGED, IN FIRST MODULE

SPECIMEN CAPACITY FOR LARGE (3.75M) AND SMALL (2.75 M) CENTRIFUGES INDICATES THAT THE LARGE CENTRIFUGE IS PREFERABLE BECAUSE OF ITS INCREASED CAPACITY FOR ANIMALS AND PLANTS AS WELL AS HUMAN SUBJECTS.

APPROXIMATE CENTRIFUGE CAPACITIES (SAAX 0307 OR 302)

DIAMETER (M)	RATS	SMALL PRIMATES	SMALL PLANTS	LARGE PLANTS	HUMANS
2.75	63	24	31	12	0
4.0	100	40	53	22	1 OR 2

EVALUATION OF LAYOUT OPTIONS FOR THE COMBINED LABORATORY (MISSION SAAX 0307) SUGGESTS THAT THE VERTICAL LAYOUT UTILIZING THE 3.75M CENTRIFUGE IS THE PREFERRED OPTION PRINCIPALLY BECAUSE IT PROVIDES MAXIMUM VOLUME FOR 0-G EXPERIMENTS AND THE CENTRIFUGE AND BECAUSE THE LARGE CENTRIFUGE CAN ACCOMMODATE HUMAN SUBJECTS.

EVALUATION OF LAYOUT OPTIONS (SAAX 0307)

CENTRIFUGE DIAMETER (M)	LAYOUT OPTION	VOL. AVAIL. 0-G EXPTS.	CENTRIFUGE VOL. AVAIL.	ADAPTABLE TO HUMAN	OPTION OVERALL RANKING
2.75	HORIZ.	CLOSE TO MINIMUM	MINIMUM	NO	4 - LOWEST
2.75	VERT.	MAXIMUM	MINIMUM	NO	3
4.0	HORIZ.	MINIMUM	MAXIMUM	YES	2
4.0	VERT.	CLOSE TO MAXIMUM	MAXIMUM	YES	1 - HIGHEST

EVALUATION OF LAYOUT OPTIONS FOR THE DEDICATED ANIMAL PLANT LABORATORY (MISSION SAAX 0302) SUGGESTS THAT THE VERTICAL LAYOUT OPTION IS FAVORED BECAUSE IT PROVIDES THE GREATEST VOLUME FOR THE LARGE DOUBLE CENTRIFUGE DESPITE THE LOW VOLUME AVAILABLE FOR 0-G EXPERIMENTS.

EVALUATION OF LAYOUT OPTIONS (SAAX 0302)

CENTRIFUGE DIAMETER (M)	LAYOUT OPTION	VOL. AVAIL. 0-G EXPTS. RANKING	CENTRIFUGE VOL. AVAIL. RANKING	ADAPTABLE TO HUMAN	OPTION OVERALL RANKING
2.75	HORIZ	2	4-LEAST	NO	6
2.75 + 2.75	VERT	3	3	NO	4
2.75	VERT	1-MOST	4-LEAST	NO	5
4.0 (DOUBLE)	HORIZ	6-LEAST	1-MOST	YES	2
4.0 (SINGLE)	HORIZ	4	2	YES	3
4.0 (DOUBLE)	VERT	5	1-MOST	YES	1

CONCEPTS CURRENTLY UNDER CONSIDERATION SATISFY THE MAJOR FUNCTIONAL REQUIREMENTS OF THE LSRF WHICH ARE:

- BIOISOLATION OF PRIMATES AND RODENTS FROM CREW.
- FLEXIBLE FACILITIES FOR HOLDING RODENTS, SMALL PRIMATES AND PLANTS.
- EXCHANGEABLE METABOLIC AND HOLDING CAGES.
- SUFFICIENT RACK VOLUME FOR BASIC RACK-MOUNTED EQUIPMENT COMPLEMENT.
- LAMINAR FLOW WORKBENCH.
- SUFFICIENT FROZEN STORAGE CAPACITY.
- MULTI-G CENTRIFUGE CAPABLE OF SUPPORTING RODENT, PRIMATE, AND HUMAN EXPERIMENTAL SUBJECTS.

ALL CONFIGURATIONS PRESENTED SATISFY THE REQUIREMENTS FOR:

- ANIMAL HOLDING FACILITIES WITH BIOISOLATION
- FACILITIES INTERCHANGEABLE TO HOLD RODENTS, SMALL PRIMATES, AND PLANTS
- METABOLIC CAGES INTERCHANGEABLE WITH STANDARD HOLDING CAGES
- HOLDING FACILITIES ADAPTABLE TO RESTRAINED LARGE PRIMATES AND RODENT BREEDING/NESTING CAGES
- VOLUME FOR THE SPECIFIED INSTRUMENTS
- ENCLOSED GERM-FREE WORKBENCH FOR MANIPULATION OF ANIMALS AND CHEMICAL PROCEDURES.
- FREEZERS FOR SPECIMEN STORAGE UNTIL RETURN
- CENTRIFUGE TO MAINTAIN ANIMALS AND PLANTS AT FRACTIONAL-G TO 1-G OR MORE, WITH POTENTIAL FOR ACCOMMODATING HUMANS FOR SHORT TIME INTERVALS

END DATE June 6, 1988